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Centralized Treatment of Metal Finishing Wastes at a Cleveland Resource Recovery Park: Part 1. Design and Costs. Part 2 Financing. Part 3. Site Investigation

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Part I: Design and Costs

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Part III: Site Investigation

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This report, in three parts, describes the characteristics of the Cleveland (OH) area electroplating industry and an approach and design for a centralized facility to treat cyanide and heavy metal wastes generated by this industry. The facility is termed the Resource Recovery Park.

Part I examines the technical feasibility of the concept, assessing the wastes of a number of platers in considerable detail and designing the treatment and recovery processes to be applied to those wastes. Part II presents the results of a marketing study intended to determine the incentives for individual plating shops to participate in the system. Part II also details the proposed management and financing plan, projecting an attractive rate of return to investors. Part III describes an investigation of a particular site and the accompanying design and costs.

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FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. The Clean Water Act, the Safe Drinking Water Act, and the Toxics Substances Control Act are three of the major congressional laws that provide the framework for restoring and maintaining the integrity of our Nation's water, for preserving and enhancing the water we drink, and for protecting the environment from toxic substances. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Water Engineering Research Laboratory is that component of EPA's Research and Development program concerned with preventing, treating, and managing municipal and industrial wastewater discharges; establishing practices to control and remove contaminants from drinking water and to prevent its deterioration during storage and distribution; and assessing the nature and controllability of releases of toxic substances to the air, water, and land from manufacturing processes and subsequent product uses. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

This report describes engineering examinations into the design and costs, the financing, and the investigation of a site for a Resource Recovery Park (RRP)--a centralized treatment facility for cyanide and heavy metal wastes generated by the electroplating industry.

Francis T. Mayo, Director
Water Engineering Research Laboratory

ABSTRACT

This report, in three parts, describes the characteristics of the Cleveland (OH) area electroplating industry and an approach and design for a centralized facility to treat cyanide and heavy metal wastes generated by this industry. The facility is termed the Resource Recovery Park.

Part I examines the technical feasibility of the concept, assessing the wastes of a number of platers in considerable detail and designing the treatment and recovery processes to be applied to those wastes. Part II presents the results of a marketing study intended to determine the incentives for individual plating shops to participate in the system. Part II also details the proposed management and financing plan, projecting an attractive rate of return to investors. Part III describes an investigation of a particular site and the accompanying design and costs.

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PART I. DESIGN AND COSTS FOR CLEVELAND RESOURCE RECOVERY PARK

SECTION 1

INTRODUCTION

The metal finishing industry in greater Cleveland is comprised of approximately 100 plants (76 within city limits), the vast majority of which are small electroplating job shops. These shops discharge an average of 18,500 gal/day of rinsewater which contains dilute concentrations of cyanide and various heavy metals used in the electroplating process. EPA's pretreatment standards[1,2] require that the discharge of these pollutants be reduced by April 27, 1984. In addition to the rinsewater, electroplating shops generate spent process solutions. Although the volumes of these solutions are relatively small (typically 300 gal/wk), the concentration of heavy metals is quite significant, often exceeding 1,000 mg/l. EPA has listed spent solutions from electroplating operations as RCRA hazardous wastes.[3]

The typical solution for compliance with electroplating pretreatment regulations is to install conventional physical/chemical treatment consisting of: cyanide oxidation, hexavalent chromium reduction, metals precipitation, and sludge dewatering. Spent solutions could also be treated in this system by slowly metering them into appropriate treatment processes. The conventional system produces a sludge which is classified by EPA as hazardous and which requires disposal in an approved landfill.

The EPA estimated capital and annual operating waste treatment costs for an average job shop are $87,400 and $22,400, respectively. This exceeds the monetary capabilities of many electroplating shops; in fact, EPA estimates that 19.9 percent of job shops will be forced to close.[4] Industry estimates on job shop closures are much higher.

The disposal of treatment sludges will also be a financial burden for many platers because of the high cost of disposal and a lack of approved landfills. Sludges often must be transported more than 100 miles to landfills where the charge for disposal may exceed $.50 per gallon.

In 1977, the EPA's Office of Research and Development (ORD) anticipated the potential impact to industry resulting from compliance with wastewater and solid waste regulations. Therefore, EPA began investigating conceptual alternatives to on-site industrial waste treatment by generators. The most promising alternative discovered to date is centralized treatment. The primary assets of this approach are economy of scale and improved waste management. This concept appears especially beneficial when resource recovery is included in the central treatment system. Not only are operating costs reduced by the value of the recovered materials, but the volume of waste treatment residuals is decreased, thereby reducing the need for hazardous waste disposal capacity. No other alternatives were considered attractive at this time.

An active role has been taken in investigating the Centralized Waste Treatment (CWT) concept, determining its applicability to the metal finishing industry, and laying the groundwork for implementation. An ORD project in 1977 established the economic feasibility of a joint waste treatment plant and investigated the legal and institutional arrangements necessary for successful implementation and operation. In 1978, ORD sponsored a second project that investigated the successful centralized treatment application in the Ruhr Valley in Germany. This same project explored the applicability of CWT to the United States, taking into account U.S. costs and U.S. environmental requirements.

In June of 1979 a third project investigated the potential use of CWT based on case studies of projected operation of systems in five municipal regions. The following regions were chosen as representative of a wide variety of U.S. industrial and demographic factors: Cleveland, Milwaukee, Philadelphia, Atlanta, and Seattle. Characteristics such as population, number of platers, platers per square mile, and population per plater were identified for each case study region. These parameters were intended to enable planners to compare their situations with one or more of the case studies performed.

The case studies used actual plant effluent data within each region to project savings based on the existence of a centralized treatment facility. Savings available within a region depend on the volumes of waste and the distances it must be shipped from the shops to the centralized facility. A close correlation between these factors was found for the five case study regions explored.

An important feature of the analysis was the use of a mathematical model which determined for each regional electroplating shop if it were more economical to use centralized treatment or to treat on site. The results of the analysis and a discussion of the CWT concept were published by EPA in June 1981.[5] The same report contains the results of another CWT project which considered its application to a small group of platers concentrated in a Providence, Rhode Island, industrial park.

In January 1981 the last CWT project, termed the Cleveland Resource Recovery Park (RRP) Project,was initiated to develop a central treatment facility design. To gather data for the design, engineering visits were made to 30 of the major electroplating shops in the area. Estimates were then made of the waste volumes and characteristics contributed by each shop to the RRP, after application of in-plant concentrating techniques.

The engineering efforts during the project were coordinated with the Cleveland Resource Recovery Park Task Force. This group comprises industry representatives, personnel from the Greater Cleveland Area Growth Association, and representatives from local utilities who provided guidance and technical assistance.

The focus of this report is on defining the components of the planned Resource Recovery Park (RRP). The results of the analysis and design are presented and a discussion of the benefits of the proposed RRP for the Cleveland metropolitan area and the participating electroplaters is developed.

SECTION 2

CONCLUSIONS

GENERAL

This project has investigated the characteristics of the Cleveland area electroplating population and developed an approach and design for a centralized facility to treat cyanide and heavy metal wastes generated by this industry. This section presents the conclusions of the research and design effort.

INDUSTRIAL CHARACTERIZATION

During the course of the project a major effort was made to collect industry data in order to characterize the Cleveland electroplating industry and to determine the local impact of environmental regulations. After available data were reviewed and organized, the additional information required was determined. Data resources included the previous centralized treatment project[6] and the effluent monitoring records of the Northeast Ohio Regional Sewer District.

After a review of the available data, 30 of the area electroplating shops were selected for engineering visits. The visits were used to collect detailed data on water use, manufacturing processes, and waste flows.

In addition to the 30 engineering visits, 5 of the shops were selected for detailed surveys. The purpose of the surveys was to collect additional information so that the costs of compliance could be determined.

The information from the five detailed surveys and the data collected during the 30 visits were later used to extrapolate wastewater flows and potential waste reductions to all Cleveland shops. This information was also used to determine the cost of compliance for the Cleveland area electroplating industry. Another task during the industrial characterization was to identify the applicable pretreatment regulations and to determine which shops would require wastewater treatment.

The result of this effort was a determination that all of the shops would be required to meet the federal pretreatment standards by January 28, 1984. Also, the local POTW plans to enforce its own pretreatment standards. The result is that for shops discharging 10,000 gpd, or more the federal standards are the controlling limits. However, for shops discharging less than 10,000 gpd, the federal limits only regulate the discharge of cyanide, lead and cadmium. For these shops the local standards will be used for other metal parameters such as nickel, chromium, copper, and zinc.

Comparing the available data to the pretreatment requirements indicated that all but 16 of the 76 shops used in the study would require some treatment. The extent of treatment needed varied from a small batch system for treating spent process solutions to a full conventional treatment system including chromium reduction, cyanide oxidation, metals precipitation and solids dewatering.

The projected cost of compliance for the Cleveland shops was calculated by determining the cost of individual treatment components (e.g., chromium reductions, metals precipitation) at various flow rates. A system was then selected for each shop based on its projected flow rate and wastewater analysis.

The results of the analysis indicate that a total investment of $4,420,000 would be required for plating shops to comply with the pretreatment standards. Only ten plants in the survey could justify the installation of dewatering equipment, and this added $465,000 to the investment cost total, yielding a projected total investment of $4,885,000.

Annual operating costs are $680,000 for the treatment system and $398,000 for sludge disposal giving a total cost of $1,078,000 per year for operating expense.

WASTE FLOWS TO THE RRP

Another major effort during the project was to forecast the volume and characteristics of the waste flows which could be expected at a centralized treatment facility. Three types of wastes were considered in this task: (1) batch dumps of exhaustible solutions, (2) rinse waters, and (3) sludges from waste treatment. Since few waste treatment systems are currently operating in Cleveland, the batch dumps and rinse waters were focused on during the investigation.

To anticipate the expected volume and characteristics of batch dumps, the information and analytical results were collected during the visits and surveys. The available data indicated that the most significant type of batch dump is spent acid dip solutions. Other types of batch dumps were either discarded less often or contained less metal contamination.

Data collected during surveys and visits showed that the typical acid (median value) dip solutions contained 854.0 mg/l of the base metal being processed. The volume of acid dip batch dumps was projected to be 240,000 gallons per year (gpy) for the 30 shops visited and 607,000 gpy for the 76 shops in the study. This entire volume was considered as a potential waste flow to the RRP.

Wastewater volumes from rinsing operations were evaluated in two ways. First, it was assumed that shops could reduce rinse water volumes using innovative rinsing techniques (e.g., series rinsing). Secondly, it was assumed that shops could use ion exchange units to collect metals and cyanide on resins which could be transported to the Resource Recovery Park (RRP). In each case it was assumed that the wastes would be segregated by metal to accommodate recovery at the RRP.

Two cases were hypothesized. In the first case it was assumed that (1) innovative rinsing would be used wherever possible and (2) ion exchange would be used elsewhere. In the second case, only ion exchange was chosen as a premise treatment alternative. For each case, two RRP capacity levels were investigated. One capacity level included all 76 of the shops in the survey. The second included only the 30 shops visited.

The results indicate that with the 30 visited shops contributing waste to the RRP, the flow will be approximately 30,000 gpd of concentrated solutions and 202 cfd of ion exchange resin (Case 1) or, if ion exchange is used exclusively, the flow rate would be 530 cfd of resin (Case 2).

Most of the larger Cleveland area shops were included in the 30 shop visits. Therefore, the flows to the RRP did not increase proportionally when all 76 shops were considered. The waste flow from all shops was projected to be 40,000 gpd of concentrated solutions and 510 cfd of ion exchange resin for Case 1 and 812 cfd of ion exchange resin for Case 2.

The weight of metals contained in the waste flows was projected at 1,050 lbs/day (Case 1) and 730 lbs/day (Case 2) for 30 shops and 1,420 lbs/day (Case 1) and 975 lbs/day (Case 2) for all shops. The majority of the metal contained in the waste flows was zinc (between 61 percent and 78 percent) with chromium making up the second largest portion (between 14 percent and 30 percent). The weights of copper, nickel and cadmium in the waste flows were found to be significantly less than zinc and chromium, resulting in much lower projections for those metals.

RESOURCE RECOVERY PARK (RRP) DESIGN, COST AND USE

The RRP treatment process design is a conventional system with ion exchange regeneration capabilities. Metal and cyanide recovery were not included in this initial design because of technical and economic considerations discussed later. The RRP design, however, is flexible to the extent that recovery processes can be incorporated in the future without significant modification.

The conventional system consists of cyanide oxidation, chromium reduction, precipitation, neutralization, clarification, thickening, and solids dewatering. Storage for raw wastes received and sludges generated at the RRP is also provided.

Two capacity designs were developed for the RRP. These include designs for all 76 Cleveland shops and for the 30 visited shops. For each design capacity it was assumed that all rinse water wastes would be received in the form of modular ion exchange units. Concentrating and transporting rinse waters were considered less practical because of handling problems and the greater potential of hazardous waste spills.

The capital and operating costs for each design were determined. For the 76-plant case the total RRP investment cost is $1,560,000. An additional $1,240,000 would be required for the purchase of ion exchange modules. It was assumed that these modules would be owned by the RRP system and leased to the plating shops. Therefore, the total capital required by the 76 plant capacity RRP is $2,800,000. The operating costs for this capacity design were calculated to be $705,000. The resulting waste treatment fee for the RRP is $0.085 per gallon of waste received or per gallon of ion exchange regeneration solution required for regeneration of received modules.

For the 30-plant capacity the RRP investment cost is $1,370,000. The ion exchange modules would cost $763,000, resulting in a total capital requirement of $2,140,000. The operating cost including transportation was calculated to be $518,000. The resulting waste treatment fee is $0.109 per gallon.

RECOVERY PROCESSES

The incentive to recover materials from plating wastes goes beyond the value of the recovered material. By using recovery at the RRP, the chemical requirements for waste treatment can be substantially reduced. The cost savings are especially significant when cyanide treatment is avoided because of the high cost for chlorine. In addition to reducing waste treatment chemical use, recovery will also reduce the volume of sludge produced at the RRP. Since sludge disposal costs are a significant operating expense for the RRP, a substantial cost savings is possible.

Recovery processes are currently available for most metals used in plating shops. However, these processes are for the most part only applicable to small waste streams and are usually applied to a single plating line within an electroplating shop. Therefore, it was necessary for the purposes of this project to design new recovery systems.

The application of recovery was considered for segregated metals solutions containing chromium, copper, zinc, cadmium, or nickel. These solutions would primarily be generated from the ion exchange regeneration processes at the RRP. In the case of chromates, spent chromic acid solution was also considered as a potential source.

For each of the five metal solutions a system was designed and costed and a simple return on investment was calculated based on variable RRP raw waste loads. The results indicated that chromium wastes provided the best opportunity for recovery with a potential return on investment (ROI) of 17 percent to 70 percent. Zinc and cadmium recovery are only marginal at the 76 plant capacity. Nickel and copper recovery are considered not feasible because of low concentrations and related waste volumes.

SECTION 3

RECOMMENDATIONS

UNDERTAKE SITE-SPECIFIC DESIGN OF CLEVELAND RRP

This project has focused on the technical feasibility of establishing a Resource Recovery Park. A parallel project covering marketing and financial aspects is currently under way. After completion of these engineering, marketing, and financial studies, the next step involves finalizing the RRP design and financing plans such that they are specific to a chosen site and operational scenario. Some alternatives for implementation, from which the particular scenario must be chosen, are:

(1) Construction on city-owned land

(2) Construction on private purchased land

(3) Establishment in existing abandoned industrial buildings, purchased

(4) Establishment within an existing industrial park

(5) Construction as part of a new planned industrial park

(6) Operation in conjunction with an existing private treater, and

(7) Operation in conjunction with an existing large plater having his own excess-capacity treatment facility.

Preliminary discussions and assessment have identified a combination of the fourth (4) and the last alternative (7) presented above as highly promising. The Woodland East Community Organization (WECO) in Cleveland, chartered in 1971 as a private non-profit corporation, has been successful in attracting new business and encouraging refurbishment of existing business within the WECO area. Metal finishing firms predominate. A variety of incentives, including federal funds, land write-downs, and industrial revenue bonds have been put together through a cooperative effort involving the city, county, Growth Association and WECO.

It is recommended that further such investigation take place, that actual embodiment of the RRP be chosen from among the alternatives presented, a site be selected, and design and financial planning be completed based on the specific approach chosen. The technical output of this effort should be completd to the extent that A&E firms could be requested to make construction bids. The financial planning should be completed to the extent that interested parties can make investment decisions.

RECOVERY ALTERNATIVES

As discussed in pages 7, the recovery processes considered for the Cleveland RRP are not yet commercially available. Therefore, before they can be incorporated into the RRP, additional engineering efforts are required.

It is recommended that continued efforts focus on recovery systems for the waste streams which are projected to provide the highest Return on Investment (ROI). The primary candidate is chromium waste. Other waste metals that should be considered are zinc and cadmium. The new efforts should include a refinement of the recovery process design and the use of pilot studies.

OBTAIN COMMITMENTS FROM THE ELECTROPLATING INDUSTRY

The Cleveland electroplating industry has shown great interest in the RRP concept and has cooperated fully in developing a design data base. It is assumed from this established relationship that the Cleveland industry will participate in the RRP system if it is economically beneficial.

It is therefore recommended that once the financial portion of the current project is completed a substantial effort be made to distribute the results of the project and obtain letters of intent for use of the RRP from interested electroplating firms.

SECTION 4

INDUSTRIAL CHARACTERIZATION

ENGINEERING VISITS

The initial population of electroplaters to be evaluated as potential participants in the Resource Recovery Park was determined to be the 76 shops identified within Cleveland City Limits. Assistance in identifying those shops was provided by the Northeast Ohio Regional Sewer District, the local chapter of the National Association of Metal Finishers, and the Task Force. Table 1 lists the facilities so identified.

A sample of 30 of the shops was selected for engineering visits. The sample was chosen to be as representative as possible of the entire population of Cleveland shops while at the same including all of the major shops. Figure 1 presents the data forms which were used in performing the engineering visits at each of the 30 shops included in the sample. The visits were completed during March-April 1981. Appendix I presents the information obtained relative to each shop.

DETAILED SURVEYS

Five of the shops visited were chosen for detailed survey and evaluation. Whereas the 30-shop visits provided data on operations and effluents, considerably more detailed study was required in order to characterize the compliance alternatives available to Cleveland electroplaters along with the associated costs. Compliance costs for each of the surveyed shops were analyzed in detail. Appendix II presents the results of those surveys.

EXTRAPOLATION TO THE ENTIRE POPULATION

The evaluation of the benefits of the proposed Resource Recovery Park requires that the costs of wastewater treatment and sludge disposal in the absence of the RRP be compared with the costs projected when the RRP is in operation. Such a comparison requires that the wastewater flows and pollutant concentrations associated with the Cleveland electroplating shops be estimated.

TABLE 1. CLEVELAND ELECTROPLATING SHOPS

Company ID Number	Volume of Sales	Gallons per Day	Number of Employees
1	-	34,460	35
2	-	30,480	-
3	1.1-5MM	123,816	15
4	-	215,244	40
5	251-500M	9,776	9
6	251-500M	52,831	21
7	-	89,430	35
8	1.1-5MM	154,686	30
9	501M-1MM	61,029	15
10	-	12,364	6
11	-	13,015	8
12	-	12,140	9
13	-	11,520	-
14	101-250M	47,164	10
15	251-500M	26,127	12
16	-	24,250	12
17	101-250M	6,156	8
18	-	4,704	6
19	501M-1MM	3,934	17
20	501M-1MM	27,219	25
21	-	2,992	3
22	101-250M	20,599	8
23	-	23,300	7
24	-	700	1
25	-	6,612	7
26	-	17,660	6
27	-	38,881	6
28	-	19,014	4
30	-	-	-
31	-	152,203	32
32	251-500M	49,607	11
33	-	24,250	12
34	-	32,912	14
35	-	8,142	5
36	501M-1MM	13,434	15
37	-	33,315	55
38	101-250M	4,151	6
39	-	66,183	50
40	-	13,404	7
41	-	2,438	4
42	Under 100M	8,280	3
43	2MM	88,383	31
44	-	4,398	6
45	251-500M	5,954	7

(Continued)

TABLE 1. (Continued)

Company ID Number	Volume of Sales	Gallons per Day	Number of Employees
46	-	3,538	4
47	101-250M	15,259	11
48	101-250M	2,116	3
49	1.1-5MM	250,954	20
50	-	14,672	120
51	-	15,939	11
52	-	71,411	30
53	501M-1MM	23,008	12
54	251-500M	8,332	14
55	-	20,570	13
56	-	2,281	3
57	-	8,100	8
58	-	3,276	7
59	251-500M	64,328	4
60	-	2,588	5
61	251-500M	4,031	15
62	251-500M	27,182	7
63	-	6,000	-
64	101-250M	15,917	7
65	251-500M	5,101	37
66	501M-1MM	239,038	60
67	251-500M	24,384	5
68	251-500M	17,660	10
69	-	71,778	40
70	-	5,325	-
71	-	20,922	12
72	1.1-5MM	85,451	31
73	-	264,941	60
74	-	27,256	11
75	-	11,504	14
76	251-500M	2,393	8

Sheet #1
Plant No. ________

PLANT DATA

PLANT NAME: ______________________ DATE: __________
STREET ADDRESS: ______________________ ENGINEER: __________
CITY: ______________ STATE: ______________ ZIP: ______
PHONE NO: ______________________ (including area code)
CONTACT: ______________________
OPERATION: ______________ (hrs/day) ______________ (days/yr)
*WATER USE: ______________ gpd DATA SOURCE: ______________
METALS PLATED: ______________________
MAJOR PARTS PLATED: ______________________

COMPOSITE SAMPLE (4hrs. min.):
START ________ STOP ________ START ________ STOP ________
EXISTING TREATMENT EQUIPMENT: ______________________

NOTES:

Figure 1. Data Forms

PLANT NAME: PLATING LINE SURVEY SHEET #2

PLANT NO.______

Line Data

Hand______________

Auto______________

Barrel______________

Prod. Rate__________

Dump Freq/Vol

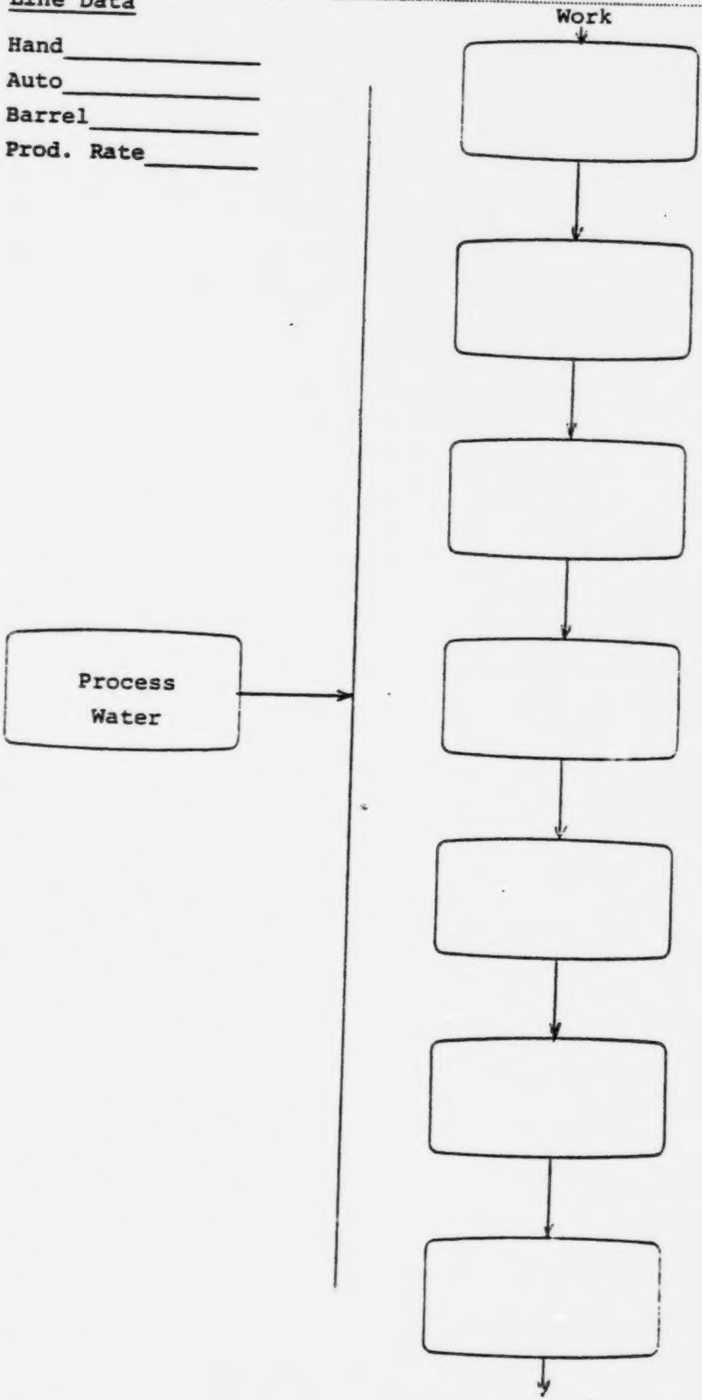

Work
Process Water

Figure 1 (Continued)

PLATING OPERATION

COMPANY: ______________________________

PLATING OPERATION (ATTACH SKETCH): ______________

BATH: ______________ TYPE: ______________

TANK NO (FROM SKETCH): ______________

BATH CONCENTRATION (oz/gal): ______________

EXPRESSED AS: __________ BATH MFGR: ______________

BATH NAME: ______________ BATH CHEM. COST ($/gal) ______
(including additives)

DRAGOUT RATE (gal/hr) ______

PLATING TANK DIMENSIONS: ______________

PLATING VOLUME (gal): ______________

PLATING OPERATING TEMPERATURE: ______________

AERATED? ______________

MAXIMUM METAL CONCENTRATION(in last rinse tank): ______

ROOM FOR _____ADDITIONAL RINSE TANKS

CAN AUTO MACHINE STATIONS BE ALTERED? ______________

OTHER SAMPLES

S#	SOURCE

NOTES:

DRAGOUT EXP

S#	(CAS) CONC	EL. TIME	PROD UNITS
1		0	0
2			
3			
4			

METAL PLTD: ______________

PARTS PLTD: ______________

RINSE TANK VOL: ______________

PLT. TANK CONC: (CAS)

Figure 1. (Continued)

Other sources of information were utilized to obtain a portion of the data. For the majority of the shops total flow rate data and an analysis of the final effluent were available from the Northeast Ohio Regional Sewer District (NEORSD). Another source of information was the 1979 study, "Centralized Treatment of Metal Finishing Wastes,"[6] during which the majority of platers in Cleveland were visited and data on operations reported.

Those shops for which information about flows associated with each plating line was lacking were assumed to have 25 percent of the total flow chromium-bearing and/or 25 percent cyanide-bearing (when the final effluent analysis revealed the presence of chromium and/or cyanide). Batch dump information was collected in detail for the 30 visited shops. Volumes and concentrations of these acid batch dumps for the remaining shops were assumed to possess the characteristics of the average of those evaluated at the visited shops.

TREATMENT COSTS IN THE ABSENCE OF THE RRP

In order to evaluate the benefits of the proposed Resource Recovery Park, it is necessary for comparison to estimate the cost associated with complying with the pretreatment requirements by conventional in-house treatment for plating shops discharging to the municipal treatment facility. The estimated cost was arrived at by:

(1) Defining the present waste flows for all Cleveland area plating shops as discussed above.

(2) Adjusting these flows to account for "normal levels" of waste reduction generally achieved prior to installation of wastewater treatment hardware.

(3) Determining the treatment requirements and equipment size for each plating shop to satisfy the limits specified for plating shops discharging wastewater into the municipal sewer system.

(4) Estimating the investment and operating cost of the treatment systems specified for each plant.

(5) Estimating the investment and operating cost associated with disposing of the sludge resulting from wastewater treatment at each plant.

(6) Determining the cost to comply with treatment requirements for the total plating shop population in the Cleveland metropolitan area.

This subsection presents the information base and the assumptions and methodology used to determine the cost of on-site treatment to comply with pretreatment requirements. Data is presented on the cost of treatment system components, general operating costs for treatment chemicals, equipment maintenance, and labor requirements and relationships defining sludge generation for treatment of metal bearing wastewater.

Pollutant Limitations

In the absence of a Resource Recovery Park, plating shops would be forced to pretreat their wastewater prior to discharge to the municipal treatment system. At a minimum, these shops must achieve the levels of pollutants specified in the National Pretreatment Standards for Electroplating Point Sources by January 28, 1984. The Northeast Ohio Regional Sewer District (NEORSD) indicated that they intend to enforce these limits. Since the federal standards do not regulate the discharge of chromium, nickel, copper and zinc for plants with a flow of less than 10,000 gal/day, NEORSD plans to also enforce existing local regulations.

Currently, very few shops in Cleveland have wastewater treatment; therefore, they face a significant investment in treatment hardware to comply with the proposed limitations.

The pollutant limitations used in this analysis for plating shops discharging wastewater to municipal sewers are shown in Table 2.

Compliance with the limits for plants discharging less than 10,000 gallons per day can be achieved as follows:

(1) Treatment of cyanide wastewaters by chemical oxidation to meet the Federal standard.

(2) Treatment of chromium wastewater to first reduce hexavalent chromium to trivalent chromium, adjust the wastewater pH to precipitate the chromium as chromium hydroxide, and clarification to remove the chromium hydroxide from the wastewater to the NEORSD standard.

(3) Treatment of waste streams containing lead, cadmium, nickel, copper, or zinc consisting of pH adjustment to reduce the metal solubility, flocculation to improve the settleability of the metal precipitant and clarification. The limits for lead and cadmium are in the Federal standard. Other metals are controlled by the NEORSD limit.

(4) Collection and treatment of spent chemical process baths prior to discharge.

TABLE 2. STANDARDS FOR PLATING SHOPS DISCHARGING WASTEWATER TO CLEVELAND MUNICIPAL TREATMENT SYSTEM

Pollutant	Federal Pretreatment Standards (mg/l)	
	Daily Maximum	4-d Average
Plants discharging <10,000 gal/d:		
Cyanide, amenable	5.0	2.7
Lead	0.6	0.4
Cadmium	1.2	0.7
Plants discharging >10,000 gal/d:		
Cyanide, total	1.9	1.0
Copper	4.5	2.7
Nickel	4.1	2.6
Chromium (Total)	7.0	4.0
Zinc	4.2	2.6
Lead	0.6	0.4
Cadmium	1.2	0.7
Silver	1.2	0.7
All metals	10.5	6.8
Hexavalent Chromium	-	-
Iron	-	-

Pollutant	NEORSD Pretreatment Standards	
	Conc. (mg/l)	Quantity (lbs/day)
Cyanide, total	-	-
Copper	3	1
Nickel	10	3
Chromium (Total)	25	25
Zinc	15	5
Lead	-	-
Cadmium	2	2
Silver	-	-
All metals	-	-
Hexavalent Chromium	10	10
Iron	50	80

Plants discharging less than 10,000 gallons per day in Cleveland will be controlled by local regulations on most common plating metals. The local regulations are generally more lenient than the federal regulations for plants discharging more than 10,000 gallons per day.

For plants discharging more than 10,000 gallons per day of wastewater, the limits in the federal regulations apply to all waste stream parameters. The cyanide oxidation, chromium reduction and metals precipitation techniques described above are applicable.

Wastewater Treatment Hardware

Compliance with the discharge limits specified in Table 2 can be achieved by conventional treatment processes widely applied to metal finishing wastewater. Depending on the pollutants present and the applicable limits, six different component systems can be utilized in the wastewater treatment system. Individual component systems include:

o Single-stage Chromium Reduction Module. This system employs a single agitated reaction tank with pH controlled addition of sulfuric acid and oxidation-reduction potential (ORP) controlled addition of sodium metabisulfite ($NaHSO_3$). The treatment only reduces hexavalent chromium to trivalent; it does not reduce the level of chromium. The single-stage system would be selected if a plant had a neutralization/flocculation/clarification system to treat other waste streams which could remove the trivalent chromium from the wastewater. Continuous systems would be used for higher flows; less expensive batch systems can treat low volume waste streams.

- Continuous Systems (see Figure 2)*,†

	Unit Cost	Installed Cost	Total Cost
<20 gpm (or <9,600 gpd)	18,000	3,000	21,000
20 to 40 gpm (9,600 to 19,200 gpd)	26,500	4,500	31,000

---

[*] Richardson Engineering Services equipment cost.

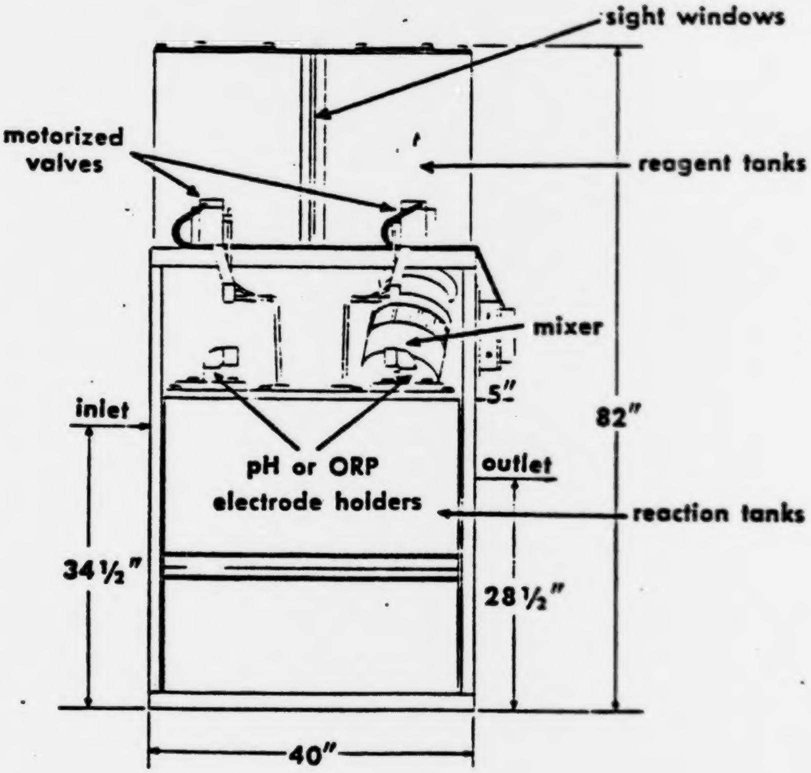
[†] Ten minutes retention in reaction tank, H_2SO_4 and $NaHSO_3$ feed automatically controlled, pre-wired control panel.

- Batch Systems [$,#]

	Total Cost ($)
<400 gpd	11,500
<800 gpd	12,900
<1,600 gpd	14,500

[$] Dual above ground tanks each sized for 4 hour retention, all required auxiliaries for automatic addition of H_2SO_4 and $NaHSO_3$ and pH and ORP probes and mixer included.

[#] Adapted from Reference 5; costs updated to 1981.


sight windows
motorized valves
reagent tanks
mixer
5"
inlet
82"
pH or ORP electrode holders
outlet
reaction tanks
34½"
28½"
40"

20 GPM System

Figure 2. Single-stage chromium reduction.

All Reagent Tanks are heavy, solid PVC with built-in transparent sight windows. The 20 GPM System Reaction Tank is heavy solid PVC. The 40 GPM Systems Reaction Tanks are heavy duty steel, vinyl coated inside and out for corrosion resistance. Instruments are supplied in a pre-wired control panel with cable for interconnection to motorized valve, probes, etc.

The system is completely and continuously automatic. Electronic control determines contamination level in reaction tank and initiates operation of system as required. Treatment starts and stops automatically without supervision.

- o Three-stage Chromium Reduction Module. Many plants discharging less than 10,000 gallons per day will only be required to treat the segregated chromium wastewaters. By employing treatment in a three module unit that successively reduces the chromates, precipitates the chromium hydroxide, and clarifies it from the wastewater, all treatment requirements can be met. Both batch or continuous treatment can be used.

  - Continuous Systems (see Figure 3)[*]

	Unit Cost	Installation Cost	Total Cost
<20 gpm (or 9,600 gpd)	26,000	4,000	30,000
20 to 40 gpm (9,600 to 19,200 gpd)	38,000	6,000	44,000

  - Batch Systems [†,§]

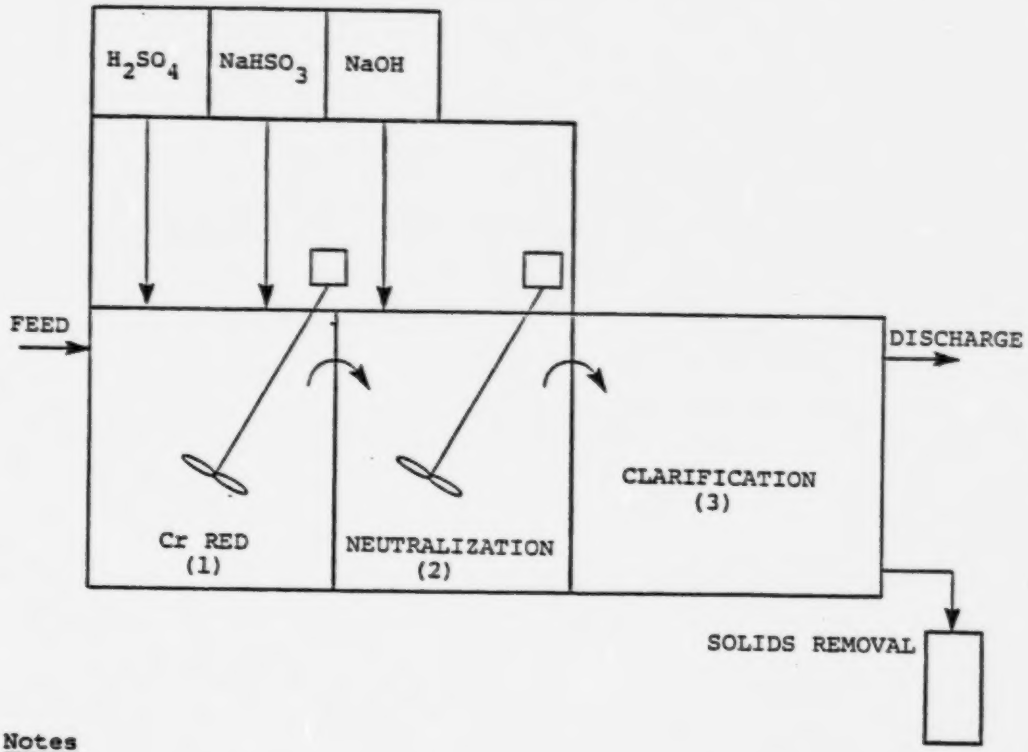
	Total Cost ($)
<400 gpd	14,400
<800 gpd	16,000
<4,000 gpd	22,000

---

[*] Adapted from Richardson Engineering Services data.

[†] Adapted from Reference 7; costs updated to 1981.

[§] Dual tanks each sized for 4 hours retention volume. Automatic batch system, auto addition of H_2SO_4, $NaHSO_3$, NaOH, gravity separation of wastewater and sludge.


H_2SO_4
$NaHSO_3$
NaOH
FEED
DISCHARGE
CLARIFICATION
(3)
Cr RED
(1)
NEUTRALIZATION
(2)
SOLIDS REMOVAL

Notes

1. pH and ORP controlled addition of H_2SO_4, $NaHSO_3$. 10 minutes retention volume at 20 gpm.
2. pH controlled addition of NaOH. 10 minutes retention volume at 20 gpm.
3. 20 minutes retention volume at 20 gpm, gravity removal of sludge.

Figure 3. Three-Stage Chromium Reduction

- Two-stage Cyanide Oxidation Module. All plating shops are required to oxidize cyanide present in the wastewater. This treatment requires control of pH and addition of sodiumhypochlorite (NaOCl) to oxidize the cyanides; they are oxidized to cyanates in the first stage and to harmless carbon and nitrogen compounds in the second stage. For plants discharging less than 10,000 gpd, the effluent from the cyanide module can be discharged if it does not also contain cadmium or lead. If flow is greater than 10,000 gpd, it must then be treated to remove metals. Again, batch or continuous treatment can be used.

  - Continuous System [*,†]

    (pH controlled addition of NaOH and ORP. Controlled addition of NaOCl into each stage.)

	Total Cost ($)
<20 gpm (or 9,600 gpd)	47,000
20 to 40 gpm (9,600 to 19,200 gpd)	54,000

  - Batch System [§,#]

	Total Cost ($)
<400 gpd	14,000
<800 gpd	15,500
<4,000 gpd	22,000

---

[*] Adapted from Reference 7; costs updated to 1981.

[†] 30 minutes retention in each stage.

[§] Adapted from Reference 7; costs updated to 1981.

[#] Dual above ground tanks sized for 4 hour retention, automatically controlled addition of NaOH, NaOCl.

All Reagent Tanks are heavy, solid PVC with built-in transparent sight windows. The 20 GPM System Reaction Tank is heavy solid PVC. The 40 GPM Systems Reaction Tanks are heavy duty steel, vinyl coated inside and out for corrosion resistance. Instruments are supplied in a pre-wired control panel with cable for interconnection to motorized valve, probes, etc.

- Three-stage Metal Removal Module. Removal of metals from mixed-metal or single metal waste streams can be accomplished by first adjusting the wastewater pH with acid or base to the point where the metals exhibit minimum solubility, slowly agitating the wastewater and adding polyelectrolyte to flocculate the particles, and then settling the precipitants in a clarification chamber. Also included is a thickener to store the dilute sludge produced by the process. Such a treatment system would generally be required for plants discharging more than 10,000 gpd or for waste streams of less than 10,000 gpd if they contained cadmium or lead. Depending on the wastewater volume, a batch or continuous unit can be used.

  - Continuous System (see Figure 4)[*]

	Total Cost ($)
<20 gpm	54,000
20 to 40 gpm	73,000
40 to 60 gpm	80,000

  - Batch System[†]

	Total Cost ($)
<2,000 gpd	16,000
2,000-4,000 gpd	21,000

All Reagent Tanks are heavy, solid PVC with built-in transparent sight windows. The 20 GPM System Reaction Tank is heavy solid PVC. The 40 GPM Systems Reaction Tanks are heavy duty steel, vinyl coated inside and out for corrosion resistance. Instruments are supplied in a pre-wired control panel with cable for interconnection to motorized valve, probes, etc.

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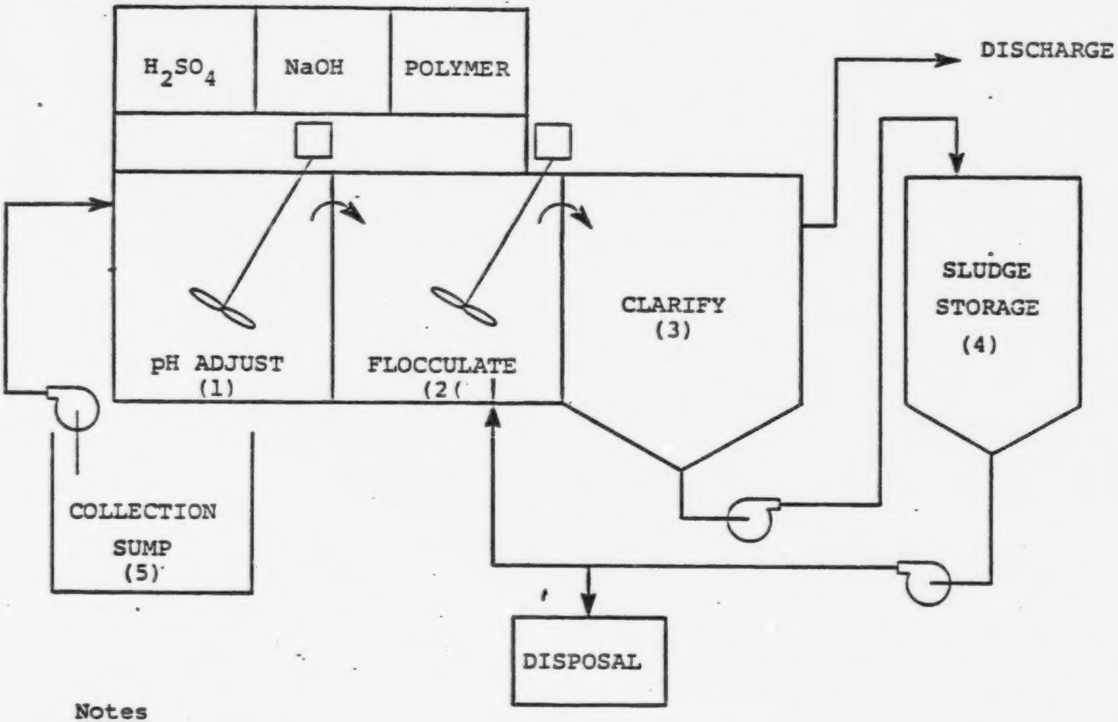
[*] Reference 4.

[†] Adapted from Reference 7; costs updated to 1981.


H_2SO_4
NaOH
POLYMER
DISCHARGE
SLUDGE STORAGE (4)
CLARIFY (3)
pH ADJUST (1)
FLOCCULATE (2)
COLLECTION SUMP (5)
DISPOSAL

Notes

1. pH controlled addition of NaOH, H_2SO_4: 10 min. retention volume.

2. 10 min. retention; slow mix with polymer.

3. 20 minute retention volume.

4. 8' high tank, volume either 2,000 or 4,000 gallons.

5. 2,000 or 4,000 gallons.

Figure 4. pH Adjust, Flocculate and Clarify

- Spent Chemical Solution Collection Sump and Pump to Meter into Treatment System. For plants with treatment systems, good operation requires that batch dumps of strong chemicals be metered into the system to avoid upsets. A collection sump and low volume feed pump will provide this capability.

Total Cost - 500 gal sump and 1 gph plastic pump - $3,000

- 1,000 gal sump and 1 gph plastic pump - $4,000

- Strong Spent Chemical Solution Collection and Treatment Sump. If the shop's combined spent rinse solutions are acceptable for discharge without treatment, the strong chemical dumps can be collected in a sump, batch treated in the same sump and then mixed with the spent rinse solutions and discharged. The treatment capabilities should consist of acid or base neutralization and either chemical oxidation or reduction.

Description - pH and ORP controlled addition of NaOH and H_2SO_4 and NaOCl or $NaHSO_3$ into agitated sump. Sump pump for discharge

Unit Cost* - 1,000 gal sump - $10,000

Unit Cost* - 2,000 gal sump - $12,000

The variety of different systems that can emerge using the six different component systems are shown in Figure 5.

Operating Cost Parameters

Operating costs associated with the wastewater treatment system are broken down into the following categories:

- Chemical reagent costs
- Maintenance costs
- Operating labor costs
- Electricity costs

All plants were assumed to operate 8 hours per day, 250 days per year. Chemical reagent costs include chemicals required for neutralization, oxidation and reduction reactions

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*Adapted from Reference 7; costs updated to 1981.

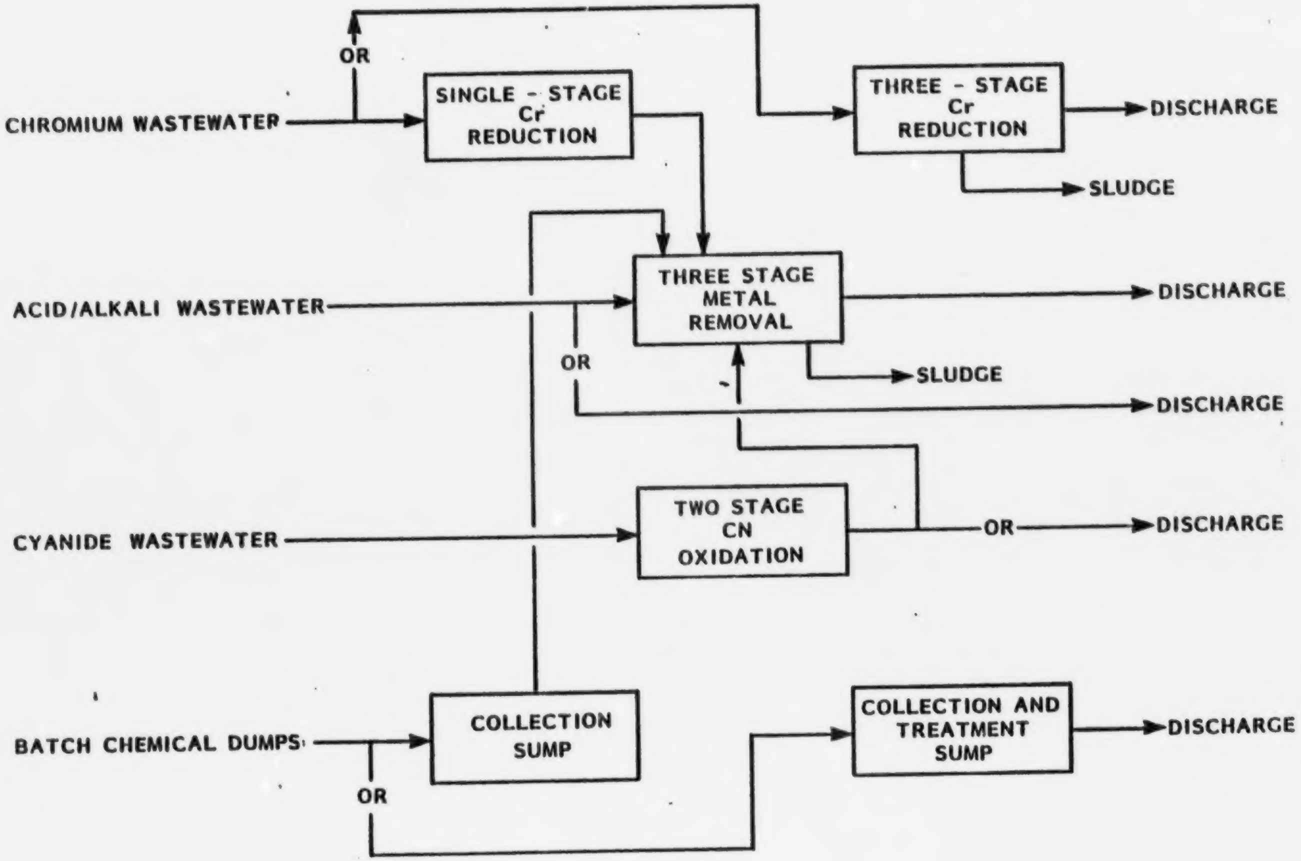

CHROMIUM WASTEWATER
OR
SINGLE - STAGE Cr REDUCTION
THREE - STAGE Cr REDUCTION
DISCHARGE
SLUDGE
ACID/ALKALI WASTEWATER
THREE STAGE METAL REMOVAL
DISCHARGE
OR
SLUDGE
DISCHARGE
CYANIDE WASTEWATER
TWO STAGE CN OXIDATION
OR
DISCHARGE
BATCH CHEMICAL DUMPS
COLLECTION SUMP
OR
COLLECTION AND TREATMENT SUMP
DISCHARGE

Figure 5. Possible treatment component configurations.

and for polyelectrolyte to aid in flocculation. Depending on the type of wastewater, the following cost factors* are used:

- Acid/alkali wastewater - \$.25/1000 gallons
- Hexavalent chromium wastewater - \$.60/1000 gallons
- Cyanide wastewater - \$3.00/1000 gallons

Maintenance costs were based on the total installed cost of the system and assumed to equal 6 percent of that amount. This cost also includes maintenance labor.

Operating labor requirements were assumed to total one hour per day for all continuous systems employed and an additional one hour per day for any batch treatment units in the treatment system. The labor rate includes any overhead charges and is assumed to be \$15.00 per hour.

Electrical costs are based on the treatment system flow rate at a rate of 6¢ per kWh according to the following formula:

< 2,000 gpd requires 5 hp - annual cost is \$450

2,000 to 10,000 gpd requires 10 hp - annual cost is \$900

> 10,000 gpd requires 20 hp - annual cost \$1,800

Sludge Disposal Costs

Removal of metals from the wastewater results in generation of a sludge which is classified in the Resource Conservation and Recovery Act (RCRA) as a hazardous waste. The cost for disposal of metal hydroxide sludges varies considerably; prices are reported to range from 25¢ to \$2.00 per gallon depending on the disposal site, distance hauled and sludge volume.[8] For purposes of estimating the cost of sludge disposal, a total cost of 50¢ per gallon, which includes hauling and disposal, was assumed. If the plant generated less than 150 gpd of sludge, it was disposed of without dewatering. Over 150 gpd, a reasonable payback (3.9 yrs, after-tax) was realized for a \$30,000 investment in a filter press dewatering system and it was assumed that the sludge was dewatered prior to shipment to a disposal site. The disposal cost was calculated based on the filter press achieving a sludge volume reduction of 90 percent.

---

*Adapted from Reference 7; costs updated to 1981.

The quantity of sludge resulting from treatment was based on the heavy metal content of the wastewater. The relationship used to determine the sludge volume is shown in Figure 6.

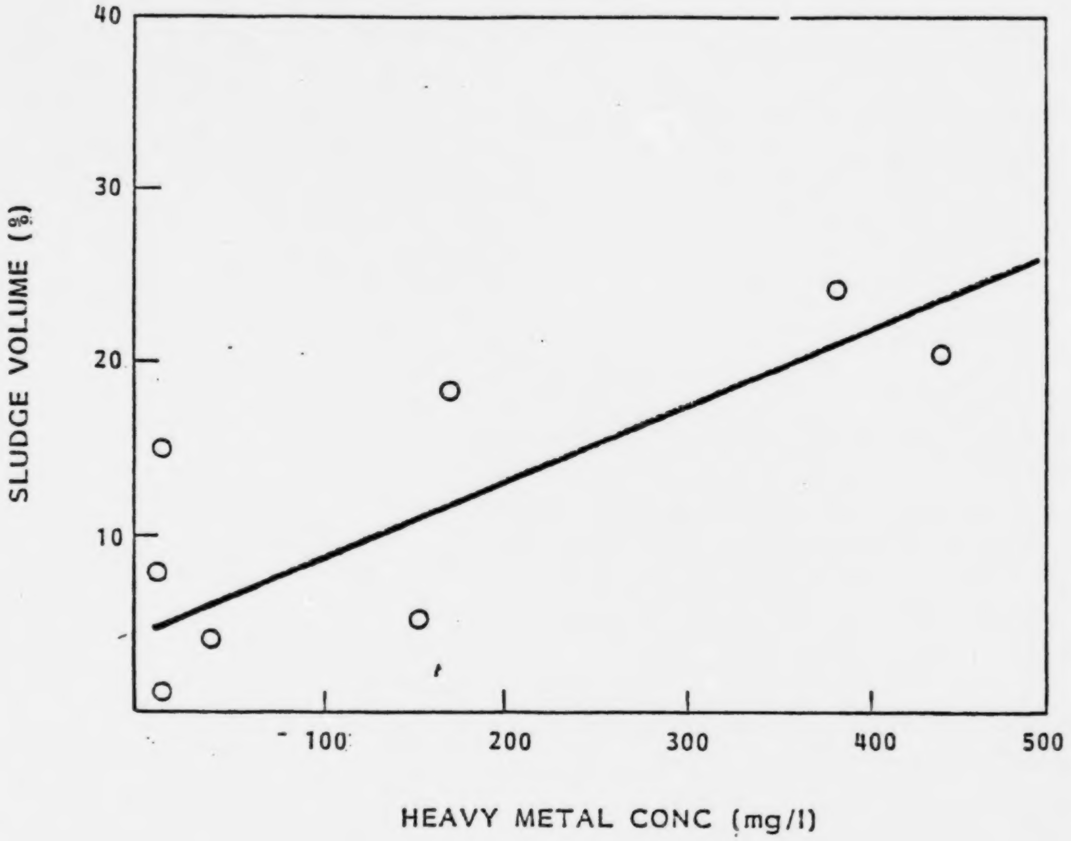
Cost to Each Plant

Engineering visits which were undertaken to define current wastewater and pollutant discharges for 30 plating shops in the Cleveland metropolitan area are described in Section 4, page 11. The information gathered during the visits also made it possible to project the waste reduction that could be achieved in each shop prior to installation of a wastewater treatment system. Flow reduction factors ranging from 10 percent to 50 percent were applied to the present flow rates. The flow reduction factor selected for each of the 30 visited shops was based on knowledge of the manufacturing process, relative flow rates in rinse tanks and ability to add rinse tanks to produce countercurrent arrangements. Additional data were supplied by NEORSD for the remaining 45 shops in the area as discussed in Section 4, page 17. In many cases, that information contained current wastewater volume and pollutant concentration data. Based on the average waste reduction at the 30 sites surveyed, a projected flow reduction rate of 20 percent was applied at the other Cleveland shops. The data that evolved enabled the cost (capital and operating) of treatment to be estimated for each shop.

Table 3 presents the wastewater flows and pollutant concentrations of the discharges from the 76 plants.

In all cases, chromium and cyanide wastes were segregated from the balance of the wastewater to allow individual treatment. Segregation of these streams is justified as it allows smaller, less expensive reduction or oxidation units to be utilized in the treatment system. If the raw data available did not indicate wastewater segregation, cyanide and chromium wastewater were assumed to each equal 25 percent of the total volume. The mass of these pollutants is kept consistent with the original data.

The treatment requirements are based on the six component systems presented in pages 20 to 27 and applied as needed to meet the discharge limitations specified on page 19. For example, Plant ID #1 discharges more than 10,000 gpd and is regulated in terms of chromium, cyanide and most common plating metals including copper and nickel. A metal removal system (System 4) is utilized to treat the acid/alkali stream (Stream B) and a single-stage chromium reduction system (System 1) is used to pretreat the chromium wastewater (Stream A). The chromium wastewater (Stream A) is then treated in the same metal removal system (System 4) to remove the trivalent chromium. The batch dumps (Stream C) are collected (System 5) and treated for



1) Volume of Sludge per Volume of Wastewater Treated After One Hour Settling. Treatment Consists of Lime Neutralization.

Source - Reference 8

Figure 6. Influence of wastewater heavy metal concentration on sludge volume.

TABLE 3. WASTEWATER TREATMENT COST EVALUATION

Plant ID	Wastewater Characteristics	Wastewater Treatment System[1]			Sludge Disposal[2]		
		Treatment Requirements[7]	Investment Cost ($)[1]	Operating Cost ($/yr)	Volume (gal/day)	Investment Cost ($)[3]	Operating Cost ($/yr)
1	A. 5052 gpd @ 53.2 mg/l Cr B. 5924 gpd @ 26.9 mg/l Cu 17.7 mg/l Ni C. 34 gpd batch dumps	A. 1, 4 B. 4 C. 5, 1, 4	116,000	13,700	72	0	9,000
2	A. 1875 gpd @ 230.4 mg/l CN B. 5625 gpd @ 19.2 mg/l Fe 5.5 mg/l Zn 42.0 mg/l Cd C. 8 gpd batch dumps	A. 3, 4 B. 4 C. 5, 4	95,000	15,900	42	0	5,300
3	Treatment System Installed	—	8,000[4]	8,000[4]	21[4]		2,600[4]
4	Surveyed[8]		75,000	34,700	100		12,500
5	Surveyed[8]		60,000	14,000	12		1,400
6	Surveyed[8]		167,000	13,400	16		2,080
7	A. 3,700 gpd @ 133 mg/l CN B. 11,100 gpd @ 140 mg/l Zn 193.7 mg/l Fe C. 44 gpd batch dumps	A. 3, 4 B. 4 C. 5, 4	118,000	23,700	214	30,000	7,600
8	A. 10,000 gpd @ 414.1 mg/l Cr	A. 2	53,000	9,300	222	30,000	7,700
9	A. 8,100 gpd @ 193.6 mg/l Cr B. 24,300 gpd @ 67.7 mg/l Cu 32.6 mg/l Zn 1.2 mg/l Cd C. 85 gpd batch dumps	A. 1, 4 B. 4 C. 5, 4	125,000	15,900	325	30,000	8,900
10	A. Wastewater in compliance B. 2 gpd batch dumps	A. N.R. B. 6	12,000	2,200	0.4	0	100

(Continued)

TABLE 3. (Continued)

Plant ID	Wastewater Characteristics	Wastewater Treatment System[1]			Sludge Disposal[2]		
		Treatment Requirements[7]	Investment Cost ($)[1]	Operating Cost ($/yr)	Volume (gal/day)	Investment Cost ($)[3]	Operating Cost ($/yr)
11	In Compliance	NR	0	0	0	0	0
12	Surveyed[9]		35,000	15,000	19		2,900
13	A. Wastewater in Compliance	A. N.R.					
	B. 175 gpd batch dumps	B. 6	12,000	2,200	35	0	4,400
14	A. 3,360 gpd @ 70.1 mg/l Cr	A. 1, 4					
	B. 2,688 gpd @ 67.8 mg/l CN	B. 3, 4					
	C. 13,200 gpd @ 1.2 mg/l Cu	C. 4					
	0.6 mg/l Cd						
	407 mg/l Fe						
	0.9 mg/l Pb						
	D. 35 gpd batch dumps	D. 5, 4	143,000	21,000	421	30,000	10,100
15	Surveyed[8]		60,000	27,700	72		11,200
16	No data		33,000[4]	9,300[4]	21[4]		2,600[4]
17	A. 1,431 gpd @ 914 mg/l Cr	A. 1, 4					
	B. 761 gpd @ 12.6 mg/l CN	B. 3, 4					
	C. 5,162 gpd @ 1.8 mg/l Ni	C. 4					
	1.8 mg/l Zn						
	2.6 mg/l Cd						
	19.4 mg/l Fe						
	D. 6 gpd batch dumps	D. 5, 4	104,000	20,000	90	0	11,300
18	A. Wastewater in compliance	A. N.R.					
	B. 7.8 gpd batch dumps	B. 6	12,000	2,200	1.6	0	200
19	A. Wastewater in compliance	A. N.R.					
	B. 242 gpd batch dumps	B. 6	12,000	2,200	48	0	6,000

(Continued)

TABLE 3. (Continued)

Plant ID	Wastewater Characteristics	Wastewater Treatment System[1]			Sludge Disposal[2]		
		Treatment Requirements[7]	Investment Cost ($)[1]	Operating Cost ($/yr)	Volume (gal/day)	Investment Cost ($)[3]	Operating Cost ($/yr)
20	A. 88.2 gpd @ 20.5 mg/l Cr B. 35.8 gpd @ 8.3 mg/l CN C. 392.3 gpd @ 15.3 mg/l Cu 26.6 mg/l Ni 0.2 mg/l Zn D. 80 gpd batch dumps	A. 1, 4 B. 3, 4 C. 4 D. 5, 4	53,000	11,200	19	0	2,400
21	A. Wastewater in compliance B. 1.3 gpd batch dumps	A. N.R. B. 6	12,000	2,200	0.3	0	0
22	A. 13,290 gpd @ 8.5 mg/l Zn 1.5 mg/l Cd 0.8 mg/l Cu 7.4 mg/l Fe B. 48 gpd batch dumps	A. 4 B. 5, 4	91,000	12,000	73	0	9,100
23	A. Wastewater in compliance B. 340 gpd batch dumps	A. N.R. B. 6	12,000	2,200	68	0	8,500
24	A. Wastewater in compliance B. 20 gpd batch dumps	A. N.R. B. 6	12,000	2,200	4	0	500
25	A. 120 gpd @ 372.2 mg/l Cn B. 480 gpd @ 88.8 mg/l Cr C. 840 gpd @ 117.3 mg/l Cu 41.3 mg/l Ni D. 28.8 gpd batch dumps	A. 3, 4 B. 1, 4 C. 4 D. 5, 4	57,000	11,600	19	0	2,400
26	A. 975 gpd @ 85.5 mg/l Cr B. 975 gpd @ 166 mg/l CN C. 1,950 gpd @ 11.2 mg/l Cu 0.9 mg/l Ni 209.2 mg/l Zn 0.8 mg/l Cd 880 mg/l Fe	A. 1, 4 B. 3, 4 C. 4	70,000	18,300	110	0	13,800

(Continued)

TABLE 3. (Continued)

Plant ID	Wastewater Characteristics	Wastewater Treatment System[1]			Sludge Disposal[2]		
		Treatment Requirements[7]	Investment Cost ($)[1]	Operating Cost ($/yr)	Volume (gal/day)	Investment Cost ($)[3]	Operating Cost ($/yr)
27	A. 3,800 gpd @ 269.2 mg/l CN B. 3,796 gpd @ 68.8 mg/l Zn 146.0 mg/l Cd C. 34 gpd batch dumps	A. 3,4 B. 4 C. 5, 3, 4	95,000	17,200	58	0	7,300
28	A. 745 gpd @ 107.4 mg/l CN B. 2,235 gpd @ 23.8 mg/l Zn 19.7 mg/l Cd 19.0 mg/l Fe C. 28.8 gpd batch dumps	A. 3, 4 B. 4 C. 5, 3, 4	50,000	11,600	21	0	2,600
29	Not used in analysis						
30	A. Wastewater in compliance B. 10 gpd batch dumps	A. -- B. 6	12,000	2,200	2	0	300
31	A. 125,000 gpd @ 107 mg/l Cd 32 mg/l Fe 44 mg/l Zn B. 62,500 gpd @ 62 mg/l CN C. 2,500 gpd @ 34 mg/l Cr	A. 4 B. 3, 4 C. 1, 4	294,000	98,400[4]	1,806[4]	90,000	31,700[4]
32	A. 9,600 gpd @ 61.2 mg/l Cr B. 6 gpd batch dumps	A. 2 B. 5, 2	56,000	9,500	65	0	8,100
33	A. 4,773 gpd @ 65.7 mg/l Cr B. 14,317 gpd @ 15.1 mg/l Ni C. Batch dumps - no data	A. 1, 4 B. 4 C. 5, 1, 4	118,000	14,200	100	0	12,500
34	A. 14,420 gpd @ 14.3 mg/l Zn B. Batch dumps - no data	A. 4 B. 5, 4	92,000	12,000	67	0	8,400
35	Wastewater in compliance		--	0	0	0	0
36	A. 9,242 gpd @ 3.6 mg/l Ni 0.3 mg/l Cu 0.1 mg/l Zn B. Batch dumps - no data	A. N.R. B. 6	12,000	2,200	39	0	4,900

(Continued)

TABLE 3. (Continued)

Plant ID	Wastewater Characteristics	Wastewater Treatment System^1			Sludge Disposal^2		
		Treatment Requirements^7	Investment Cost ($)^1	Operating Cost ($/yr)	Volume (gal/day)	Investment Cost ($)^3	Operating Cost ($/yr)
37	A. 20,937 gpd @ 7.9 mg/l Ni B. Batch dumps - no data	A. 4 B. 5, 4	101,000	12,900	91	0	11,400
38	1,928 gpd @ 62.0 mg/l Cr	2	26,000	6,000	13	0	1,600
39	No data		33,000^4	9,300^4	21^4		2,600^4
40	7,755 gpd @ 34.4 mg/l Cr	2	36,000	8,000	43	0	5,400
41	Wastewater in compliance		--	0	0	0	0
42	A. 1,499 gpd @ 145.2 mg/l CN B. 4,495 gpd @ 15.6 mg/l Cu 0.6 mg/l Ni 2.4 mg/l Zn 12.6 mg/l Fe C. Batch dumps - no data	A. 3, 4 B. 4 C. 5, 4	95,000	15,500	24	0	3,000
43	Has treatment		--	9,300^4	21^4		2,600^4
44	A. 2,550 gpd @ 240 mg/l Cr B. 7,650 gpd @ 49.5 mg/l Ni 16.8 mg/l Cu	A. 1, 4 B. 4	113,000	12,300	90	0	11,300
45	A. 1,209 gpd @ 13.6 mg/l CN B. 3,627 gpd @ 2.6 mg/l Cu 2.9 mg/l Ni 1.1 mg/l Zn 3.3 mg/l Cd 7.3 mg/l Fe	A. 3, 4 B. 4	91,000	15,000	17	0	2,100
46	Wastewater in compliance		--	0	0	0	0
47	Wastewater in compliance		--	0	0	0	0

(Continued)

TABLE 3. (Continued)

Plant ID	Wastewater Characteristics	Wastewater Treatment System[1]			Sludge Disposal[2]		
		Treatment Requirements[7]	Investment Cost ($)[1]	Operating Cost ($/yr)	Volume (gal/day)	Investment Cost ($)[3]	Operating Cost ($/yr)
48	No data		33,000[4]	9,300[4]	21[4]		2,600[4]
49	A. 87,500 gpd @ 3 mg/l Cu 76 mg/l Zn 11 mg/l Cd 140 mg/l Fe B. 43,750 gpd @ 6 mg/l Cr C. 43,750 gpd @ 140 mg/l CN	A. 4 B. 1, 4 C. 3, 4	246,000[4]	76,800[4]	1,450[4]	75,000	26,400[4]
50	A. 25,600 gpd @ 364.0 mg/l Zn 88.0 mg/l Fe B. Batch dumps - no data	A. 4 B. 5, 4	101,000	13,200	612	30,000	12,500
51	Wastewater in compliance	N.R.	--	0	0	0.	0
52	Has treatment		--	9,300[4]	21[4]		2,600[4]
53	Has treatment		--	9,300[4]	21[4]		2,600[4]
54	Wastewater in compliance		--	0	0	0	0
55	A. 10, 650 gpd @ 48 mg/l Cu @ 80 mg/l N @ 190 mg/l Zn @ 7 mg/l Cd @ 40 mg/l Fe @ 7 mg/l Pb B. 5,300 gpd @ 325 mg/l Cr C. 5,300 gpd @ 90 mg/l CN	A. 4 B. 1, 4 C. 3, 4	170,000[4]	21,200[4]	312[4]	30,000	8,700[4]
56	Wastewater in compliance		--	0	0	0	0
57	Wastewater in compliance		--	0	0	0	0
58	A. 314 gpd @ 54.6 mg/l Cr B. 943 gpd @ 5.9 mg/l Cd 1.9 mg/l Zn	A. 1, 4 B. 4	33,000	10,200	6	0	800
59	3,342 gpd @ 201.5 mg/l Cr	2	26,000	6,700	43	0	5,400
60	A. 1,414 gpd @ 187.8 mg/l Zn 0.9 mg/l Ni 65.0 mg/l Fe	A. 4	19,000	5,400	21	0	2,600

(Continued)

TABLE 3. (Continued)

Plant ID	Wastewater Characteristics	Wastewater Treatment System[1]			Sludge Disposal[2]		
		Treatment Requirements[7]	Investment Cost ($)[1]	Operating Cost ($/yr)	Volume (gal/day)	Investment Cost ($)[3]	Operating Cost ($/yr)
61	2,635 gpd @ 56.0 mg/l Cr	2	26,000	6,600	17	0	2,100
62	A. 2,500 gpd @ 18.0 mg/l Cr B. 7,500 gpd @ 8.3 mg/l Cu 6.2 mg/l Ni 2.1 mg/l Zn 7.8 mg/l Fe C. 15 gpd batch dumps	A. 1, 4 B. 4 C. 5, 1, 4	116,000	13,400	53	0	6,600
63	No data		33,000[4]	9,300[4]	21[4]		2,600[4]
64	No data		33,000[4]	9,300[4]	21[4]		2,600[4]
65	Wastewater in compliance	N.R.	--	0	0	0	0
66	No data		33,000[4]	9,300[4]	21[4]		2,400[4]
67	9,750 gpd @ 14.7 mg/l Cr & Machining	2	53,000	9,200	45	0	5,600
68	Wastewater in compliance	N.R.	--	0	0	0	0
69	A. 3,766 gpd @ 34.8 mg/l Ni 0.3 mg/l Zn 0.2 mg/l Cu	A. 4	26,000	6,400	20	0	2,400
70	Wastewater in compliance	N.R.	--	0	0	0	0
71	No data		33,000[4]	9,300[4]	21[4]		2,600[4]
72	37,725 gpd @ 49.7 mg/l Cr	1, 4	133,000	17,200	233	30,000	7,800
73	A. 95,900 gpd @ 12.8 mg/l Cu @ 2.5 mg/l Ni @ 48.0 mg/l Zn @ 44.0 mg/l Cd @ 54.0 mg/l Fe @ 0.3 mg/l Pb B. 47,900 gpd @ 328 mg/l Cr C. 47,900 gpd @ 480 mg/l CN	A. 4 B. 1, 4 C. 3, 4	476,000	87,000[4]	1,940[4]	90,000	33,400[4]
74	No data		33,000[4]	9,300[4]	21[4]		2,400[4]

(Continued)

TABLE 3. (Continued)

Plant ID	Wastewater Characteristics	Wastewater Treatment System[1]			Sludge Disposal[2]		
		Treatment Requirements[7]	Investment Cost ($)[1]	Operating Cost ($/yr)	Volume (gal/day)	Investment Cost ($)[3]	Operating Cost ($/yr)
75	Wastewater in Compliance	N.R.	--	0	0	0	0
76	2,788 gpd @ 179.5 mg/l Cr	2	26,000	6,000	33	0	4,100
	Median Value[5]		33,000	9,300	21	0	2,600
	Average Value[5]		61,900				
	Totals[6]		4,412,000	920,700	9,457	465,000	398,200

1) All plants assumed to operate 8 hrs/day; 5 days/week.

2) Sludge disposal cost based on 50¢ per gallon hauling plus disposal cost.

3) Investment in filter press justified at sludge rates of greater than 150 gpd.

4) Based on median value of plants where waste stream is defined.

5) Based on plants where data on effluent quality was obtained.

6) Based on total for all 75 plants.

7) Legend for Treatment Requirements

1. Single-stage chromium reduction.
2. Three stage chromium reduction (reduction, neutralization, clarification).
3. Two-stage cyanide oxidation.
4. Treatment consisting of pH control, flocculation and clarification with sludge storage/thickening.
5. Batch dump collection and bleed into treatment system.
6. Batch dump collection and treatment.

8) Treatment costs were calculated for five surveyed shops under Task 2.

9) Plant operates 3 shifts per day.

chromium reduction (System 1) and metal removal (System 4). Consequently, System 1 is sized for a flow of 5,086 gpd and System 4 is sized for 11,010 gpd.

As another example, Plant ID #20 has less than 10,000 gpd and employs chromium and cyanide plating. The acid/alkali waste stream (Stream C), which contains only copper, nickel, and zinc, must be treated to comply with the local limitations. The low flow chromium waste stream (Stream A) is treated in a batch chromium reduction system (System 1) that reduces the hexavalent chromium. Similarly, the cyanide wastewater (Stream B) is treated in a batch cyanide oxidation unit (System 3) before discharge. Metal removal from the cyanide, chromium and acid/alkali wastes is achieved with a batch neutralization, flocculation, solid separation treatment.

The investment costs to provide the treatment requirements are based on the costs presented for the six subsystems in pages 20 to 27 and are shown for each plant in the fourth column of Table 3. The total cost of the components is increased by 20 percent to account for site preparation and engineering fees. For the few plants that had flows in excess of the capacity of the system for which costs are presented, the cost was calculated by multiplying the system cost by the ratio of flow to system capacity taken to the 0.6 power. The median investment cost of the treatment system was calculated for the 65 plants where data was available. The 65 plants included those where analysis indicated the wastewater was in compliance and no system investment is required and those where no investment is required because the treatment was already installed. The median price system is $33,000 and this cost is used for plants where no data is available.

It should be pointed out that the required investment does not include the wastewater segregation that would be necessary to treat the different types of wastewater, e.g., cyanide, chromium, acid/alkali. This cost is not included as it would be incurred regardless of whether wastes are treated in-house or at a central treatment site.

Also not included in the investment amount is the cost for any new building space. It is reasonable to assume that most plants could fit the treatment system in their existing buildings and no direct cost would result. There would be a reduction in available floor space, however, and the use of floor space does have an associated cost.

The operating cost, shown in Column 5, is calculated according to the basis presented in pages 20 to 27 and includes treatment reagents, maintenance, labor and electricity. No fixed operating cost for equipment depreciation is included in the operating cost.

As an example of the operating cost calculation, consider Plant ID #2. The costs will be as follows:

- Reagent Costs

  1,875 gpd CN x $3/1,000 gal x 250 d/yr = $1,400/yr

  5,625 gpd A/A x $.25/1,000 gal x 250 d/yr = $350/yr

- Maintenance

  $95,000 x .06 = $5,700/yr

- Labor

  Batch CN - 1 hr/day x 250 d/y x $15/hr = $3,750/yr

  Continuous Units - 1 hr/day x 250 d/y x $15/hr = $3,750/yr

- Electricity

  7,508 gpd requires 10 hp @$900/yr

Total = $15,850 per year

Costs for sludge disposal are based on total disposal cost of 50¢ per gallon. As explained in pages 29 and 30, if sludge generation rates exceeded 150 gallons per day, the investment in a filter press dewatering system is justified and disposal cost will be based on the cost of disposing of the dewatered sludge plus the cost of operating and maintaining the equipment.

The results of the analysis indicate that a total investment of $4,412,000 would be required for plating shops to comply with the pretreatment standards. Only ten plants in the survey could justify the installation of dewatering equipment and this added $465,000 to the investment cost total, yielding a projected total investment of $4,877,000.

Annual operating costs are $679,100 for the treatment system and $398,200 for sludge disposal for a total cost of $1,318,900 per year.

The average and median of each of the cost items is indicated in Table 2. The median investment cost for the treatment system was $33,000. The cost was lower than the average cost ($61,900) due to the number of shops which did not require any hardware to achieve compliance.

SECTION 5

PROJECTED MATERIAL FLOWS TO THE RRP

Section 4 presented the characterization of the 76 Cleveland electroplaters and the costs estimated to result from their compliance with expected regulations through on-site treatment.

This section presents results of an analysis performed to project the waste flow rates to the Cleveland Resource Recovery Park when local electroplating shops send their wastes to the RRP rather than treating on-site. In making the waste flow estimates, it is assumed that electroplating shops will concentrate their wastestreams using either innovative rinsing techniques or ion exchange. Two projections have been calculated. In the first projection only the 30 shops at which engineering visits were made are considered. The second projection includes all Cleveland area electroplating shops.

This section presents the assumptions and methodology used to calculate the waste flow projections. Included are discussions of which electroplating wastestreams are significant, the effects of innovative rinsing and ion exchange on waste volume, and the two waste flow projections.

IDENTIFICATION OF WASTE STREAMS

Introduction

The waste streams from electroplating operations can be divided into three basic categories:

- Batch dumps of exhaustible solutions
- Rinse waters
- Sludges from waste treatment

Currently in Cleveland very few electroplating shops have a waste treatment system that produces a sludge. Therefore, batch dumps and rinse waters are of primary concern in this initial waste projection analysis. The following subsections present the assumptions used to identify these wastestreams for the Cleveland shops.

Batch Dumps of Exhaustible Solutions

During the 30-plant survey, it was observed that several types of process solutions were routinely discarded (usually discharged into the sewer). These included alkaline or soak cleaners, acid dip solutions, chromate solutions and phosphate solutions. The alkaline cleaners and acid dip solutions were almost universally used and discarded on a weekly or monthly basis. The other solutions were used less frequently and discarded only in certain instances. Data on dump frequency and waste constituents were generally less available for these solutions. Therefore, the alkaline cleaners and acid dip solutions were focused upon in the waste projection analysis.

Data collected during the 30 shop visits and 5 surveys indicated that there was a significant difference in the metal content between alkaline cleaners and acid dip solutions. Also, within each of these waste categories there was considerable variation. Tables 4 and 5 summarize batch dump data collected during the visits and surveys. The typical (median valve) alkaline cleaner (either electro-clean or electroless cleaner) had a pH of greater than 12.9 and a relatively low metal content of less than 48 mg/l. Most acid dip solutions had a pH of less than 1.0 and a relatively high concentration of metals. The metal content of the acid dip solutions often exceeded 1,000 mg/l.

Since the metal content of alkaline cleaners is relatively small, it contributes very little to the overall pollutant content of electroplating wastewater. For instance, if an electroplating shop is discharging 30,000 gallons per day of rinse water with a chromium concentration of 2.0 mg/l and a 300 gallon batch dump containing 50 mg/l of chromium is added to the discharge, the average effect is an increase of only 0.5 mg/l. Therefore, unless the metal content of an alkaline cleaner is unusually high or the waste is in some way hazardous, it can be slowly metered to the sewer and have little effect on the concentration of the rinse water waste stream.

However, the metal content of the acid dip solutions is generally high enough to cause serious effluent violations. For instance, if a 300 gallon acid dip solution containing 750 mg/l chromium is discharged to the sewer along with a rinse water discharge of 30,000 gpd containing 2 mg/l, the average effect would be an increase of 7.4 mg/l.

TABLE 4. ANALYSIS OF ALKALINE CLEANER SOLUTIONS

Sample Code	Volume (gal)	Dump Frequency (weeks)	pH	Metal Analyzed*	Conc. (mg/l)
4-1	500	4	12.7	Zinc	23.7
4-2	1000	6	13.03	Zinc	388.0
4-21	350	26	13.11	Copper	4.5
4-26	350	26	NA	Copper	2.97
4-35	200	2	12.44	Zinc	105.0
4-36	400	2	13.10	Zinc	536.0
4-47	200	1	13.01	Zinc	428.0
4-48	200	1	12.7	Zinc	18.0
5-1	325	NA	12.64	Copper	58.1
5-2	390	NA	12.54	Chromium	37.5
5-23	NA	NA	NA	Chromium	36.0
5-24	NA	NA	NA	Chromium	8.2
6-1	338	4	12.97	Zinc	47.9
6-14	338	4	12.98	Zinc	162.0
6-26	253	12	12.62	Chromium	98.2
6-34	456	8	13.08	Zinc	168.0
6-35	913	8	13.01	Zinc	95.5
6-50	349	0	13.04	Cadmium	122.0
15-6	340	26	12.97	Zinc	4.2
15-1	340	26	12.88	Zinc	74.0
Average	402.33	9.75	12.87		120.89
Median	340	4	12.97		47.9

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*Metal analyzed was the metal plated on that particular line.

TABLE 5. ANALYSIS OF ACID DIP SOLUTIONS

Sample Code	Volume (gal)	Dump Frequency (weeks)	pH	Metal Analyzed*	Conc. (mg/1)
4-5			.17	Zinc	55,600
4-23	300	26	NA	Copper	1.69
4-38	200	1	NA	Zinc	854.0
4-39	200	1	.02	Zinc	714.0
4-50	200	1	NA	Zinc	1060.0
4-51	200	1	.25	Zinc	1090.0
5-8	40	NA	NA	Copper	10600.0
5-22	140	NA	.03	Zinc	365.0
6-3	151	4	3.53	Zinc	664.0
6-16	182	4	NA	Zinc	694.0
6-28	64	12	1.54		36.1
6-37	228	6	.51	Zinc	4960.0
6-38	228	6	.41	Zinc	13800.0
6-52	60	0	.25	Cadmium	7600.0
6-63	165	8	.36	Cadmium	1990.0
6-69	30	8	.05	Cadmium	9.4
15-3	50	2	.01	Zinc	750.0
15-8	50	2	.01	Zinc	5240.0
15-28	NA	NA	NA	Zinc	355.0
Average	146	5.5	0.55		5,599.1
Median	165	4	0.25		854.0

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*Metal analyzed was the metal plated on that particular line.

Based on these observations from the visitation and survey data it was concluded that, in general, platers would discharge alkaline cleaners to the sewer and send acid dip solutions to the RRP.

Rinse Waters

Rinse waters comprise the vast majority of the wastewater volume resulting from electroplating operations. In Cleveland, the average flow rate per shop from rinsing is approximately 50,100 gallons per day (median flow rate is approximately 20,700 gpd).*

The waste constituents and the pollutant concentration of individual rinses vary according to the constituents of their associated process tank. Rinses following plating tanks usually contain concentrations of the plated metal well in excess of the 1984 federal pretreatment standards. The only exceptions are on plating lines where parts are intermittently plated and rinses are constantly flowing. The rinses following plating processes will be a major source of waste for the RRP.

Many rinses, however, contain concentrations of metals below federal pretreatment standards and can be discharged to the sewer without metal removal. These include most rinses following alkaline cleaners and some rinses following acid dip solutions. For instance, a single overflow rinse flowing at 3 gpm following an alkaline cleaner containing 50 mg/l of zinc will theoretically contain 0.3 mg/l zinc when the dragout rate is 1.0 gph. Considering similar conditions for a rinse following an acid dip solution with a zinc concentration of 750 mg/l, the zinc concentration of the rinse water would be 4.25 mg/l. Therefore, in general rinses following alkaline cleaners are not expected to be received at the RRP. Rinses following acid dip solutions must be considered on a case by case basis.

PROJECTING WASTE STREAM VOLUMES

Introduction

As identified in pages 42 to 46 the major waste streams that are expected at the RRP include spent acid dip solutions and rinse waters following plating solutions or acid dip solutions. The expected volume of acid dip solutions is relatively simple to project since most shops discharge these solutions on a regular basis (e.g., weekly or monthly). This information was collected during the 30-shop visits. Available data on volumes of dumped acid dip solutions are presented in Table 6. The data have been extrapolated to project volumes expected at the RRP for the 30 shops and all 76 major shops identified during the study.

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*Flow rate data for 30 shops supplied by Northeast Ohio Regional Sewer District (NEORSD).

Projecting rinse water flows to the RRP is a more difficult task. Most present rinsing practices involve the use of single overflow rinses, parallel rinses, and 2-stage countercurrent rinses. These rinsing methods result in waste stream flows of 2 to 20 gallons per minute (gpm) with relatively low concentrations of metals. Knowing that the rinse waters would be transported to the RRP by truck, it is obvious that such flow rates are prohibitive. Therefore, concentration of the waste streams must be performed.

Many Cleveland electroplating shops have the potential for changing rinsing procedures to utilize innovative configurations which concentrate rinse waters. These rinsing techniques are usually inexpensive to implement and therefore provide a very cost effective method of waste concentration. However, some shops, especially those with automatic plating machines, are unable to change rinsing techniques. It is assumed that in such cases ion exchange will be used to collect metallic waste constituents. The ion exchange resins could then be transported to the RRP for regeneration.

Recovery of metals from rinse waters is an objective of the RRP. Since effective metal recovery is difficult from wastes containing several metals, it will be necessary for the shops to keep the concentrated rinse water and ion exchange resins segregated by metal. For instance, a shop with a copper-nickel-chromium plating line will need to install 3 separate storage tanks for the concentrated rinse waters of the three plating solutions. If ion exchange were used instead of innovative rinsing, then 3 separate ion exchange canisters would be used, each servicing a specific rinse water.

The following subsections discuss the technical assumptions that were used in calculating the waste flows from innovative rinsing and ion exchange technologies.

Estimating Waste Flows From Innovative Rinsing

To accurately estimate the waste flows from an individual shop it is necessary to evaluate the rinsing process on a tank by tank basis. This approach was applied in this analysis by using data collected during the 30 shop visits and other information collected during the centralized waste treatment project[6] in 1980.

Various rinsing configurations are possible for any given set of rinse tanks. For instance, if a plating bath is

TABLE 6. ACID DUMP DATA (28 SHOPS)

Plant Code	Volume of Tank (gal)	Frequency (wks)	Volume per Year (gal)
07	800	15	2773
01	120	4	1560
	120	26	240
	120	26	240
	120	4	1560
	120	4	1560
	120	4	1560
	120	26	240
19	350	2	9100
09	250	2.5	5200
	250	2.5	5200
	150	2.5	3120
	150	2.5	3120
25	375	26	750
28	200	4	2600
	200	4	2600
30	140	4	1820
	531	15	1841
	157	15	544
	97	13	388
	120	13	480
13	284	8	1846
	220	1	11440
22	250	4	3250
	200	4	2600
	100	6	867
	100	12	433
08	0	0	0
14	400	1	20800
18	40	6	347
20	200	1	10400
26	0	0	0
31	200	2	5200
	200	2	5200
	400	2	10400
	200	2	5200
	300	2	7800

TABLE 6 (Continued)

Plant Code	Volume of Tank (gal)	Frequency (wks)	Volume per Year (gal)
17	130	8	845
24	100	8	650
03	200	2	5200
27	170	1	8840
23	250	6	2167
05	63	1	3380
04	1000	4	13000
	300	26	600
	200	1	10400
	200	1	10400
	200	1	10400
	200	1	10400
06	151	4	1963
	182	4	2366
	64	12	277
	228	6	1976
	228	6	1976
	165	8	1073
15	50	2	1300
	50	2	1300
21	55	8	358
10	120	12	520
12	50	4	650
	50	12	217
02	530	14	1969
	160	14	594
		Total 28	223,800
		Total 30	239,786*
		Total 76	607,457*

---

*Extrapolated Value

followed by three rinse tanks, the rinse tank configuration alternatives include: 3-stage counter current, 1 dragout tank and a 2-stage counter current; 2 dragout tanks and a single overflow rinse. Tradeoffs exist between various rinsing configurations and when evaluated can indicate which configuration is most economical. The major cost factors to consider include:

- Water and sewer
- Additional rinse tanks
- Treatment chemicals
- Sludge disposal
- Plating chemicals
- Storage and hauling (for centralized treatment only)

As an example of tradeoffs, consider the difference between a 3-stage countercurrent rinse and a recovery tank with a 2-stage countercurrent rinse. Although each system uses 3 rinse tanks, water use, plating chemical loss, treatment chemical requirements and the other cost factors differ significantly. In a nickel plating operation with a plating bath temperature of 140°F, nickel concentration of 85,000 mg/l and a 1.0 gph dragout rate, the water use and plating chemical loss differ by a factor of 2 and 4.5 respectively. (The 3-stage countercurrent configuration uses less water but chemical loss is high since none of the plating solution is recovered.) Taking into account all major cost factors, the difference in annual costs between these two rinsing systems is about $15,600 in favor of the system incorporating the recovery tank.

Each rinsing system in Cleveland could be evaluated in a similar manner. However, this time consuming task is not necessary. Instead, by evaluating several typical situations, it is possible to identify some general rules for selecting the optimal rinsing configuration.

The factors which most affect the selection of a rinsing configuration are plating bath temperature and dragout rate.

The temperature of the bath has a direct effect upon evaporation. As the temperature of the bath increases, the evaporation rate (gallons per square foot of tank surface area) also increases thereby allowing for recovery of dragout solution. If a bath is operated at ambient temperature, only a small volume of water will be evaporated and the direct recovery of rinse water is minimal.

The dragout rate has a somewhat different effect on the selection of an optimal rinsing configuration. As the dragout rate increases, it is necessary to use more water to clean the workpiece to some desired level. The result is that rinsing configurations such as 2 dragout rinses and one overflow rinse, which are recovery oriented require too much water and become less cost effective.

In calculating recovery rates and water usage with various recovery rinsing configurations, a relationship between evaporation rate and dragout is often used. It is referred to as the recycle rinse ratio (r) and it is calculated as follows:

$$r = \frac{\text{evaporation rate}}{\text{dragout rate}}$$

The analysis presented in this report focused on two variables, bath temperature and dragout rate, to identify which rinsing configurations are best for each set of conditions when sending waste to the RRP.

For the evaluation, two types of plating baths were considered: chromium and nickel. Typical bath concentrations and operating temperatures were assumed for each bath.* Plating baths that are normally operated at ambient temperature (such as cadmium) were not evaluated since direct recovery is minimal and the optimal configuration is usually countercurrent rinsing.

Nine different rinsing configurations were considered in the analysis (Figure 7). The dragout rates for nickel and chromium plating were varied from 1 to 2 gallons per hour (gph). The analysis is presented in Tables 7 through 14.

The rinsing cost analysis can be utilized to make general conclusions about the choice of optimal rinsing configurations. The conclusions expressed below consider recovery ratio (r) values for common plating solutions and typical operating conditions.

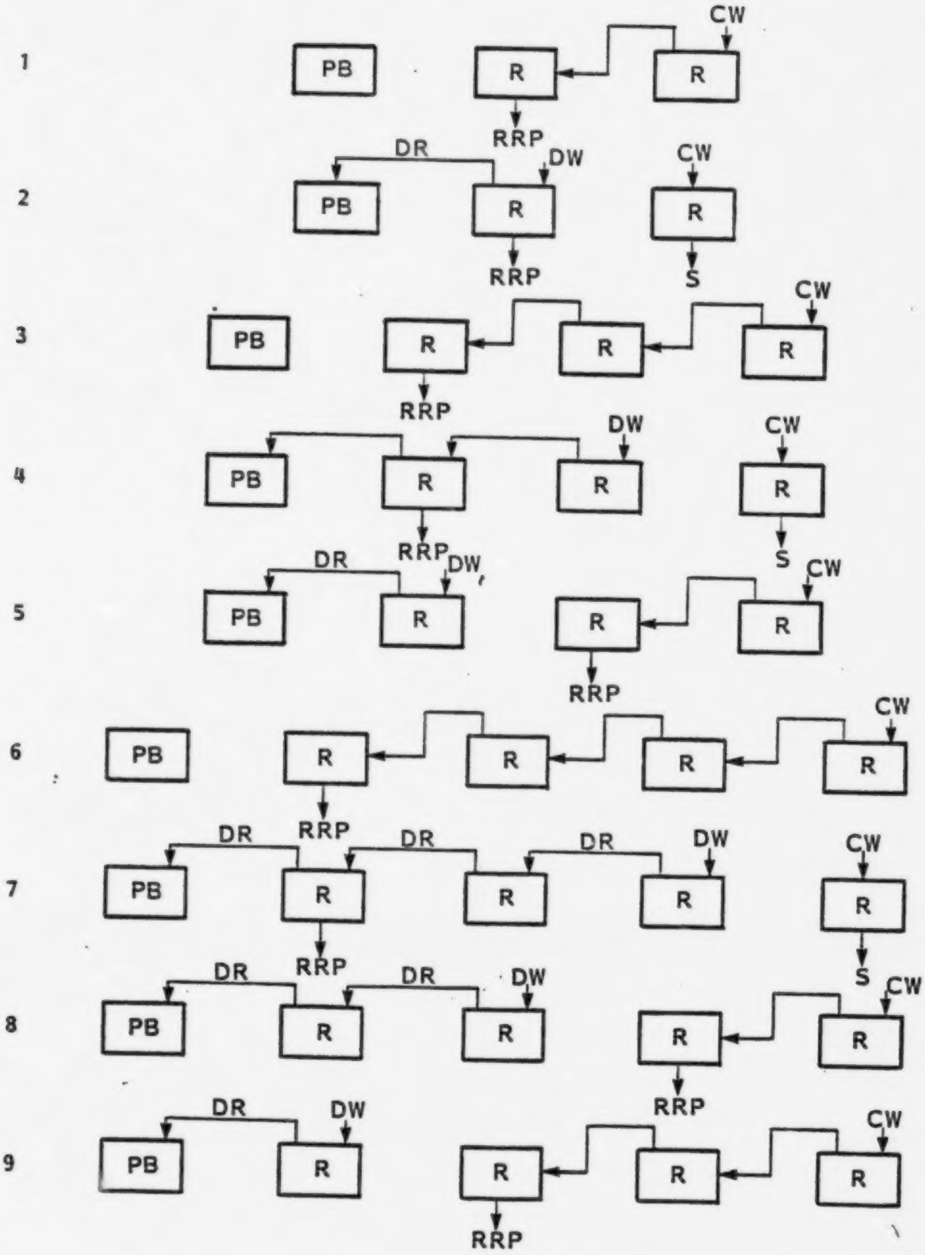
- Plating baths in temperature range of 90-110°F

  2-Rinses

  If $r \geq 1.25$ use configuration 2
  If $r < 1.25$ use configuration 1

---

*Chromium: 200,000 mg/l Cr, 110°F; nickel: 85,000 mg/l Ni, 140°F.


1
PB
R
R
CW
RRP
2
DR
PB
R
DW
R
CW
RRP
S
3
PB
R
R
R
CW
RRP
4
PB
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R
R
CW
RRP
9
DR
PB
R
DW
R
R
R
CW
RRP

PB - PLATING BATH
R - RINSE
CW - CITY WATER
DW - DEIONIZED WATER
RRP - FLOW TO RESOURCE RECOVERY PARK
DR - DRAGOUT RECOVERY
S - FLOW TO SEWER (W/OUT TREATMENT)

Figure 7. Rinsing configurations

TABLE 7. RINSING SYSTEM EVALUATION CHROMIUM PLATING - 1 GPH DRAG-OUT

Rinsing System	Water Use: GPM to Sewer	GPH to RRP	1,000 G/Y to RRP	1,000 G/Y to Sewer	Plating Chemicals Lost: lb Cr/Yr to Treat.	lb Cr/Yr to Sewer
1	0	78	324	0	6,950	0
2	6	45.3	188	1498	6,607	149
3	0	12	50	0	6,950	9
4	6	4.6	19	1498	5,624	149
5	0	54	225	0	6,950	0
6	0	6	25	0	6,950	0
7	6	2.6	11	1498	4,524	149
8	0	42	175	0	4,692	0
9	0	18	75	0	3,336	0

TABLE 8. RINSING SYSTEMS COST EVALUATION CHROMIUM PLATING - 1 gal/h DRAG OUT

	Water & Sewer $2/1000 Gal	Additional Rinse Tanks $240/Tank	Hauling Cost $13/1000 gal	Treatment Chemicals		Sludge $1.48/lb Cr	Plating Chemicals Lost $4.20/lb Cr	DI Water $	Storage[†] Tanks	Total $
				$.41/lb Cr	$.28/1000 gal					
1	648	240	4,212	2,850	91	10,286	29,190	0	1,246	48,745
2	3,372	240	2,444	2,709	53	9,778	27,749	1,080	723	48,148
3	100	480	650	2,850	14	10,286	29,190	0	200	43,770
4*	3,034	480	247	2,306	5	8,324	23,621	1,080	200	39,297
5	450	480	2,925	1,368	63	4,937	14,011	1,080	865	26,179
6	50	720	325	2,850	7	10,286	29,190	0	200	43,628
7	3,018	720	143	1,855	3	6,696	19,001	1,080	200	32,716
8	350	720	2,275	798	49	2,880	8,173	1,080	673	16,998
9	150	720	975	1,368	21	1,937	14,011	1,080	289	20,550

---

*High rinse rate required with this option to meet maximum allowable concentration in the final rinse (35 mg/l Cr). This may preclude the use of this option.

[†] Flow (1000 gal) to RRP divided by 52 and multiplied by $400 and min. of $200.

TABLE 9. RINSING SYSTEM EVALUATION CHROMIUM PLATING - 2 GPH DRAG-OUT

Rinsing System	Water Use				Plating Chemicals Lost	
	GPM to Sewer	GPH to RRP	1,000 G/Y to RRP	1,000 G/Y to Sewer	lb Cr/Yr to Treat.	lb Cr/Yr to Sewer
1	0	150	624	0	13,900	0
2	6	184	766	1498	13,689	149
3	0	18	75.0	0	13,900	0
4	6	202	84.2	1498	12,872	149
5	0	126	524	0	9,313	0
6	0	6	25	0	13,900	0
7	6	8.4	34.7	1498	11,935	149
8	0	114	474	0	7,500	0
9	0	36	150	0	9,313	0

TABLE 10. RINSING SYSTEMS COST EVALUATION CHOMIUM PLATING - 2 gal/h DRAG OUT

	Water & Sewer $2/1000 Gal	Additional Rinse Tanks $240/Tank	Hauling Cost $13/1000 gal	Treatment Chemicals		Sludge $1.48/lb Cr	Plating Chemicals Lost $4.20/lb Cr	DI Water $	Storage Tanks	Total $
				$.41/lb Cr	$.28/1000 gal					
1	1,248	240	8,112	5,699	175	20,572	58,380	0	2,400	96,826
2	4,528	240	9,958	5,612	214	20,259	57,493	1,080	2,946	102,330
3	150	480	975	5,699	21	20,572	58,380	0	288	86,565
4*	3,164	480	1,094	5,278	24	19,051	54,062	1,080	324	84,557
5	1,048	480	6,812	3,818	147	13,783	35,115	1,080	2,015	68,298
6	50	720	332	5,699	7	20,572	58,380	0	100	85,860
7*	3,065	720	451	4,893	10	17,663	50,127	1,080	133	78,142
8	948	720	6,162	3,075	133	11,100	31,500	1,080	1,823	56,541
9	300	720	1,950	3,818	42	13,783	39,115	1,080	577	61,385

---

*High rinse rate required with this option to meet maximum allowable concentration in the final rinse (35 mg/l Cr). This may preclude the use of this option.

TABLE 11. RINSING SYSTEM EVALUATION NICKEL PLATING - 1 GPH DRAG-OUT

	Water Use				Plating Chemicals Lost	
Rinsing System	GPM to Sewer	GPH to RRP	1,000 G/Y to RRP	1,000 G/Y to Sewer	lb Ni/Yr to Treat.	lb Ni/Yr to Sewer
1	0	42	175	0	2,950	0
2	6	26.5	110	1498	2,580	97
3	0	12	50	0	2,950	0
4	6	7.75	32	1498	2,104	97
5	0	24	100	0	650	0
6	0	6	25	0	2,950	0
7	6	0.7	2.75	1498	586	97
8	0	18	75	0	177	0
9	0	12	50	0	650	0

TABLE 12. RINSING SYSTEMS COST EVALUATION NICKEL PLATING - 1 gal/h DRAG OUT

	Water & Sewer $2/1000 Gal	Additional Rinse Tanks $240/Tank	Hauling Cost $13/1000 gal	Treatment Chemicals $.18/lb Ni	Treatment Chemicals $.21/1000 gal	Sludge $1.15/lb Ni	Plating Chemicals Lost $6.35/lb Ni	DI Water $	Storage Tanks	Total $
1	350	240	2,275	531	37	3,393	18,733	0	673	26,232
2	3,216	240	1,430	464	23	2,967	16,383	1,080	423	26,226
3	100	480	650	531	11	3,393	18,733	0	200	24,098
4	1,000	480	416	379	7	2,420	13,360	1,080	200	19,342
5	200	480	1,300	117	21	748	4,127	1,080	385	8,452
6	50	720	325	531	5	3,393	18,733	0	200	23,957
7	3,000	720	36	105	1	675	3,727	1,080	200	6,844
8	150	720	975	32	16	204	1,123	1,080	865	8,169
9	100	720	650	117	11	748	4,127	1,080	200	7,753

TABLE 13. RINSING SYSTEM EVALUATION NICKEL PLATING - 2 GPH DRAG-OUT

	Water Use				Plating Chemicals Lost	
Rinsing System	GPM to Sewer	GPH to RRP	1,000 G/Y to RRP	1,000 G/Y to Sewer	lb Ni/Yr to Treat.	lb Ni/Yr to Sewer
1	0	84	349	0	5,900	0
2	6	120	499	1498	5,842	97
3	0	12	50	0	5,900	0
4	6	13.8	58	1498	4,991	97
5	0	60	250	0	1,300	0
6	0	6	25	0	5,900	0
7	6	5.7	24	1498	3,900	97
8	0	42	174	0	354	0
9	0	18	75	0	1,300	0

TABLE 14. RINSING SYSTEM COST EVLUATION NICKEL PLATING - 2 gal/h DRAG OUT

	Water & Sewer $2/1000 Gal	Additional Rinse Tanks $240/Tank	Hauling Cost $13/1000 gal	Treatment Chemicals		Sludge $1.15/lb Ni	Plating Chemicals Lost $6.35/lb Ni	DI Water $	Storage Tanks	Total $
				$.18/lb Ni	$.21/1000 gal					
1	698	240		1,060	73	6,785	37,465	0	1,342	47,663
2*	3,994	240		1,051	105	6,718	37,096	1,080	1,919	52,203
3	100	480		1,060	11	6,785	37,465	0	200	46,103
4*	3,112	480		898	12	5,740	31,692	1,080	223	43,237
5	500	480		310	53	1,978	10,922	1,080	962	16,285
6	50	720		1,060	5	6,785	37,465	0	200	46,285
7	3,044	720		702	5	4,485	24,765	1,080	200	35,001
8	348	720		78	37	483	2,667	1,080	669	6,082
9	180	720		314	16	2,001	11,049	1,080	288	15,648

---

*High rinse rate required with this option to meet maximum allowable concentration in the final rinse (50 mg/l Ni). This may preclude the use of this option.

  3-Rinses

    Always use configuration 5

  4-Rinses

    Always use configuration 8

- Plating bath in temperature range of 120-160°F

  2-Rinses

    If $r \geq 2.75$ use configuration 2
    If $r < 2.75$ use configuration 1

  3-Rinses

    Always use configuration 5

  4-Rinses

    If $r \geq 2.75$ use configuration 7
    if $r < 2.75$ use configuration 8

- Plating bath at ambient temperature

  2-Rinses

    Always use configuration 1

  3-Rinses

    Always use configuration 3

  4-Rinses

    Always use configuration 6

Results of Rinse Water Flow Rate Calculations

The approach described in pages 47 and 50 to 61 was applied to the Cleveland area shops using the visitation and survey data of the present effort described in Appendices I and II supplemented by information collected during the 1978 Centralized Treatment Project.[6] Flow rates for the various rinsing configurations and ion exchange were calculated using equations presented in several literature sources.[7,10,11]

Two cases were investigated. In Case I innovative rinsing techniques were applied where possible and ion exchange was applied to the remaining rinses. In Case II ion exchange was used exclusively.

The results for the individual shops are presented in Tables 15 and 16, and a summary is presented in Table 17.

The results indicate that with the 30 visited shops contributing waste to the RRP the flow will be approximately 30,141 gpd of concentrated solutions and 202.5 cfd of ion exchange resin (Case 1) or, if ion exchange is used exclusively, the flow rate would be 528.7 cfd of resin (Case 2).

Since most of the larger Cleveland area shops were included in the 30 shop visits, the flows to the RRP do not increase proportionally when all 76 shops were considered. The waste flow from all shops was projected to be 39,950 gpd of concentrated solutions and 513.4 cfd of ion exchange resin for Case 1 and 811.6 cfd of ion exchange resin for Case 2.

The weight of metals contained in the waste flows was projected at 1,051.3 lbs/day (Case 1) and 730.4 lbs/day (Case 2) for 30 shops and 1,423.7 lbs/day (Case 1) and 975.5 lbs/day (Case 2) for all shops. The majority of the metal contained in the waste flows was zinc (between 61 percent and 78 percent) with chromium making up the second largest portion (between 14 percent and 30 percent). The weight of copper, nickel and cadmium in the waste flows was significantly less than zinc and chromium.

Figures 8 and 9 provide an interesting view of these results. The first chart shows the potential contribution of metals to the RRP from the 76 Cleveland shops. The total weight of metals is 1048 lbs/day. As indicated, the vast majority of metal (86%) is contributed by 11 of the 76 shops, and approximately one-half of the metal is contributed by only 3 shops. This indicates the importance of the large shops to the success of the RRP.

Figure 9 provides a breakdown by metal of the 1048 lbs.day. As shown, more than one-half (55%) of the metal is zinc. Chromium accounts for about 30% and the remaining metals are in significantly lesser quantities (cadmium (7%), nickel (6%) and copper (2%)).

TABLE 15. WASTE FLOWS TO THE RRP FROM RINSING

PLATING SOLUTION

	Copper			Chromium			Nickel		
Plant #	Conc. GPD	Conc. mg/l	IX CF/Day	Conc. GPD	Conc. mg/l	IX CF/Day	Conc. GPD	Conc. mg/l	IX CF/Day
1			1.1			1.2			1.1
2									
3			6.6						5.2
4	1464	804.7				3.6			
4									
5							124	590.7	
6							40.5	552.6	
6									
7									
7						2.2			
8						38.5			
9	28.1	2509.3							
10									
11						0.8			0.5
12									
13									
14						1.1			
14									
15									
15									
16									
17						5.0			
18									
19									0.4
19									
20	849.9	442		152.8	1175.1		271.7	993.9	
21									
22									
23									
24									
25				77.8	884.1		80.8	693.9	
26						0.4			
27	98	1084.5							
28									
30									
31						22.1			
31									
31									
32						2.8			
33						1.5			0.9
34									
35									
36									0.2
37							15.0	1104.6	
38									
39									0.6
40				717.59	1357.81				

(Continued)

TABLE 15. (Continued)

	PLATING SOLUTION					
	Zinc			Cadmium		
Plant #	Conc. GPD	Conc. mg/l	IX CF/Day	Conc. GPD	Conc. mg/l	IX CF/Day
1						
2				69.6	3437.5	
3						
4	3276.0	7802.2				
4						
5						
6	369.0	1153.0		269.1	825.0	
6	368.1	1155.8				
7	401.0	1157.8				
7						
8						
9	684.0	1158.1				
10						
11						
12						
13			0.9			
14	1157.6	5110.60		82.7	670.9	
14	4136.0	5109.7				
15	991.2	619.0				
15	1155.7	227.5				
16						
17						
18						
19	32.4	7792.9				
19				13.5	9351.4	
20			0.4			
21						
22	16.0	7036.0		21.6	2595.6	
23						
24						
25						
26			3.2			
27	100.8	7795.5		16.4	3437.6	
28						
30	158.4	1153.4				
31	5349.7	1158.2		724.8	3431.4	
31	795.0	7794.3				
31	309.0	20053.5				
32						
33						
34			1.7			
35						
36						
37						
38						
39			1.0			
40						

(Continued)

TABLE 15. (Continued)

PLATING SOLUTION

	Copper			Chromium			Nickel		
Plant #	Conc. GPD	Conc. mg/l	IX CF/Day	Conc. GPD	Conc. mg/l	IX CF/Day	Conc. GPD	Conc. mg/l	IX CF/Day
41									
42									
43									
44						2.9			1.6
45									
46									
47									
48									
49									
50									
51									
52									
53						2.2			7.2
54									
55			3.8			8.2			3.5
56									
57									
58									
59				272	1303.7				
60									
61						0.7			
62	76.5	1152.5					57.0	584.5	0.98
63									
64									
65									
66									
67						0.7			
68									
69									5.5
70									
72				852.0	1448.8				
73						74.4			
74									
75									0.2
76						2.6			

(Continued)

TABLE 15. (Continued)

PLATING SOLUTION

Plant #	Zinc			Cadmium		
	Conc. GPD	Conc. mg/l	IX CF/Day	Conc. GPD	Conc. mg/l	IX CF/Day
41						
42						
43						
44						
45				65.6	674.0	
46						
47						
48						
49			53.7			5.1
50			75.0			
51						
52						
53						
54			16.5			
55						
56						
57						
58						
59						
60			2.1			
61						
17						
62						
63						
64						
65						
66						
67						
68			4.1			
69						
70						
72						
73						22.3
74						
75						
76						

TABLE 16. WASTE FLOWS TO THE RRP FROM RINSING (USING ION EXCHANGE ONLY)

Plant #	Copper (CF Resin/Day)	Chromium (CF Resin/Day)	Nickel (CF Resin/Day)	Zinc (CF Resin/Day)	Cadmium (CF Resin/Day)
1	1.1	11.3	1.2		
2					1.2
3	6.6		5.3		
4	4.9	2.2		205.6	
5			0.5		1.2
6			0.7	6.8	
7		2.2			
8		38.5			
9	2.4	7.4		6.4	
10					
11		0.8	0.5		
12					
13				0.9	
14		1.1		22.5	
15				1.9	
16					
17		5.0			
18					
19			0.4	2.1	
20	3.9	2.18	2.5	0.4	
21					
22				0.9	
23					
24					
25		0.4	1.1		
26		0.4		3.2	
27	0.9			6.4	2.9
28					
30				1.5	
31		22.1		149.8	13.3
32		2.8			
33		1.4	0.9		
34				1.7	
35					
36			0.2		
37			0.7		
38		0.6			
39			0.6	1.1	
40		2.6			

(Continued)

TABLE 16. (Continued)

Plant #	Copper (CF Resin/Day)	Chromium (CF Resin/Day)	Nickel (CF Resin/Day)	Zinc (CF Resin/Day)	Cadmium (CF Resin/Day)
41					
42	0.6				
43					
44		2.9	1.6		
45					
46					
47					
48					
49				53.7	5.1
50				81.4	
51					
52					
53			7.2		
54					
55	3.8		3.5	16.5	
56					
57					
58					
59		3.5			
60				2.1	
61		0.7			
62	0.4		0.2		
63					
64					
65					
66					
67		0.7			
68				4.1	
69			5.5		
70					
72		9.7			
73		74.4		37.0	22.3
74					
75			0.2		
76		2.6			

TABLE 17. SUMMARY OF WASTE FLOWS FROM RINSING

		Cu	Cr	Ni	Zn	Cd
30 SHOPS - CASE 1						
Volume of Concentrated Rinse Water	(gpd)	2,440	226	517	13,569	1,202
Weight of Metals in Concentrated Rinse water	(lbs/day)	14.4	2.0	3.5	421.5	27.2
Volume of IX* Resin	(cfd)	7.7	75.0	7.3	4.5	0
Weight of Metals in Resins	(lbs/day)	8.4	131.8	13.3	4.4	0
Total Wt. of Metals	(lbs/day)	22.8	123.8	16.9	425.9	27.2
30 SHOPS - CASE 2						
Volume of IX* Resin	(cfd)	19.6	83.6	12.0	405.7	11.6
Weight of Metals in Resin	(lbs/day)	21.0	146.9	22.0	393.5	28.1
ALL SHOPS - CASE 1						
Volume of Conc. Rinse water	(gpd)	2,517	4,367	589	13,569	1,268
Wt. of Metals in Conc. Rinse Water	(lbs/day)	15.2	23.4	3.9	421.5	27.6
Volume of IX* Resin	(cfd)	11.5	171.0	26.9	192.5	16.4
Wt. of Metals in Resin	(lbs/day)	12.3	277.6	49.2	186.7	39.8
Total Wt. of Metals	(lbs/day)	27.5	301.0	53.1	608.2	67.3
ALL SHOPS - CASE 2						
Volume of IX* Resin	(cfd)	24.3	195.9	32.5	593.6	28.5
Wt. of Metals in Resin	(lbs/day)	26.0	318.1	59.6	575.8	68.9

---

*IX - Ion Exchange

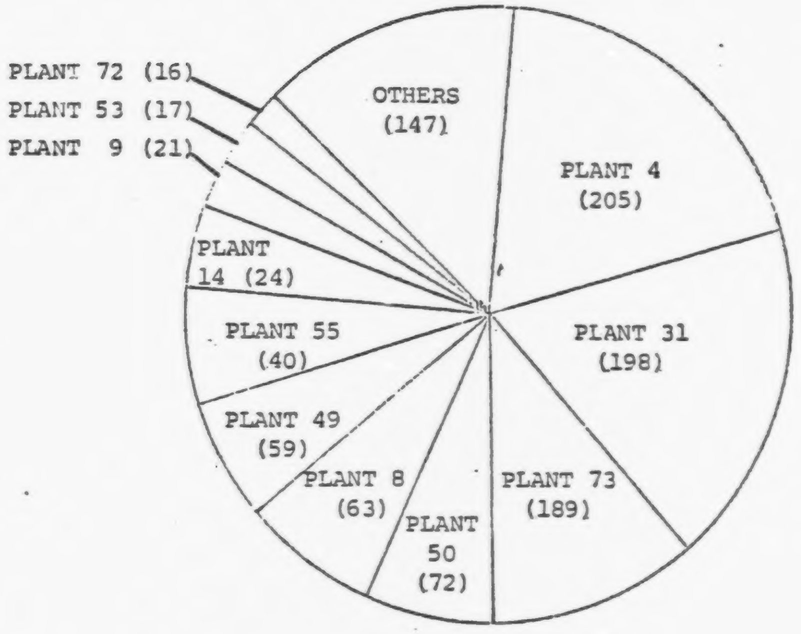


Figure 8. Potential contribution of metals to RRP from 76 Cleveland shops - total 1048 lbs metal/day.

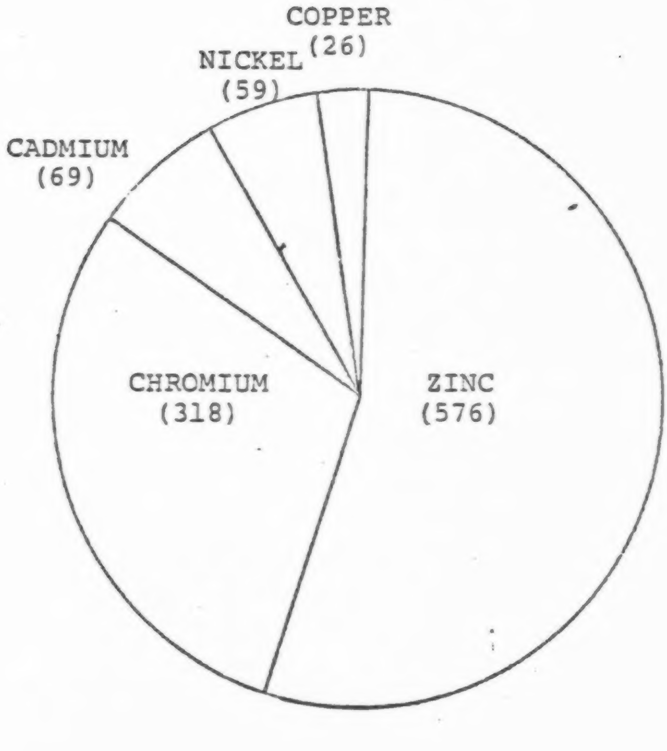


Figure 9. Potential quantities of individual metals from 76 Cleveland Shops to RRP - Total 1048 lbs. metal/day.

SECTION 6

RESOURCE RECOVERY CAPABILITIES OF CENTRAL TREATMENT FACILITY

The metal content of waste products from metal finishing and electroplating facilities is a recoverable resource. The economic incentive to reclaim the material is derived from three benefits:

- Recovery of raw material value
- Avoidance of treatment costs
- Avoidance of disposal costs

Limitations of currently available technology require that in order to recover the metal content, single metal waste must be segregated from wastes containing different metals. Recovery from the single metal waste can be achieved using process components that have been proven in similar commercial applications. Waste segregation would be the responsibility of the industrial waste generator. In order to encourage the industrial community to practice waste segregation, an economic incentive must be available. Therefore, the cost they incur in maintaining the waste's value should be balanced by reduced treatment fees charged by the recovery facility.

Wastes containing copper, nickel, chromium, cadmium, or zinc are potential resource materials. Each waste requires a dedicated recovery loop that can operate independently, or as part of a larger system. Financial justification of a recovery system is dependent on the feed material available for processing. Table 18 indicates the different waste products and the investment required; also shown is the amount of waste needed to obtain a reasonable return on the investment capital.

In Cleveland, there are 76 metal finishing shops within city limts, the assumed service area of the RRP. Table 19 presents the return on investment for the recovery systems at different levels of participation. As shown, chromium wastes are well in excess of the minimum amount required if full participation of the Cleveland shops is achieved. Nickel and copper recovery systems are not feasible with only these waste volumes. Zinc and cadmium are only marginal at full participation.

TABLE 18. QUANTITY OF WASTE MATERIAL REQUIRED FOR RECOVERY SYSTEM ECONOMIC FEASIBILITY

Waste Material	Recovery System Investment ($)	Products	Feed Rate Required for 30% ROI*
Chromates	290,000	Na_2CrO_4 or H_2CrO_4	163 lb Cr per day
Copper	120,000	Cu metal and NaCN	122 lb Cu (as CuCN) per day
Zinc	430,000	Zn metal and NaCN	450 lb Zn (as ZnCN) per day
Cadmium	120,000	Cd metal and NaCN	86 lb Cd (as CdCN) per day
Nickel	103,000	Ni metal	160 lb Ni per day

*Simple pretax ROI.

Note - Assumptions underlying analysis are presented in text.

TABLE 19. IMPACT OF LEVEL OF PARTICIPATION OF CLEVELAND SHOPS ON RECOVERY SYSTEM

	ROI*	Profitability		
Waste	Case 1A	Case 2B	Case 2A	Case 2B
Chromium	17	21	63	70
Copper	NR	NR	NR	NR
Zinc	NR	16	NR	33
Cadmium	NR	NR	NR	20
Nickel	NR	NR	NR	NR

---

*Simple pretax ROI.

NR - No return.

As shown for chromium in Figure 10, the return on investment in a metal recovery system improves rapidly as the amount of waste available for recovery increases. In order to take advantage of the economy of scale, the services should be provided to a broader range of industries and where economical, accept wastes from industry outside the Cleveland city limits.

CHROMATE RECOVERY SYSTEM

Chromic acid is widely used in the electroplating industry for chromium plating, metal stripping, and as an etchant for both metal and plastic parts prior to plating.[12] In each case, the active constituent in the solution is the hexavalent chromium or chromate compound; trivalent chromium, which normally accumulates in these solutions, is considered a contaminant.

Industrial wastes containing chromates fall into the following categories:

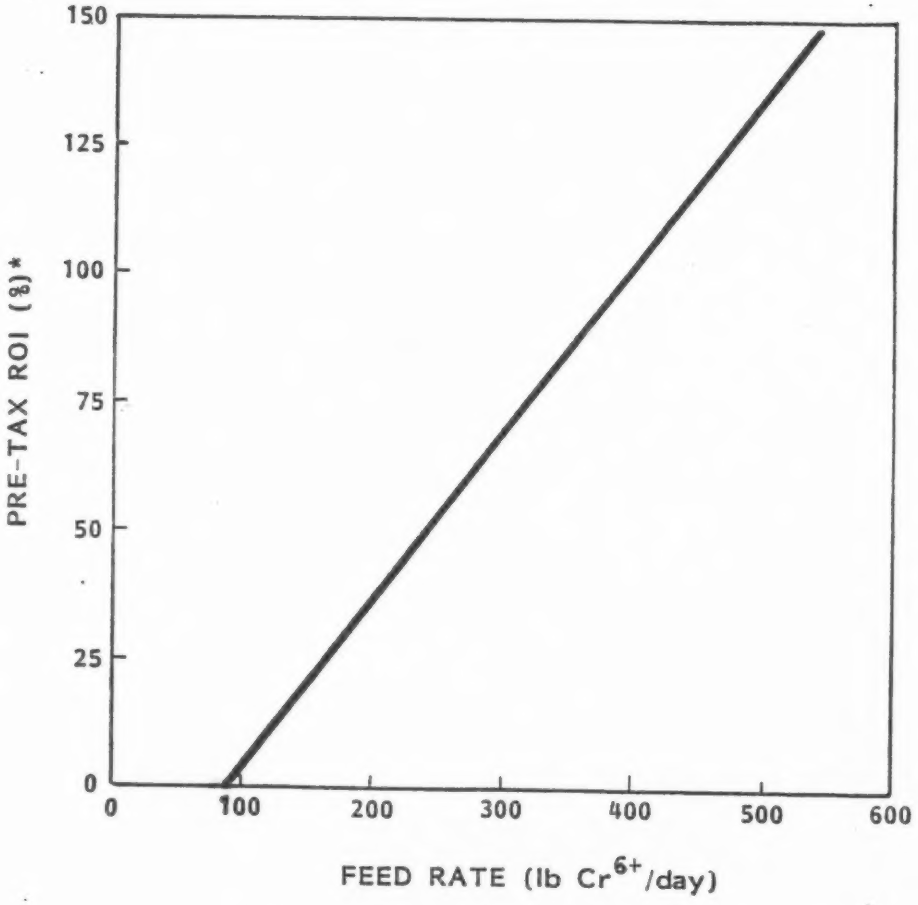
- Contaminated chromium plating baths - Concentrated chromic acid solutions contaminated with high levels of trivalent chromium and other metal cations (e.g., Fe, Cu, Ni).

- Spent chromate etchants - Moderate concentration chromate solutions contaminated primarily with trivalent chromium; if the etchant is for metal surface preparation, it will also contain metal cations.

- Spent copper stripping chromate solutions - Moderate concentration of chromates contaminated with trivalent chromium and copper cations.

- Rinses after chromium plating, etching or stripping processes - Dilute chromate solutions containing trivalent chromium and other metal cations, in addition to a background level of normal water contaminants (e.g., Na, Ca, CO_3, SO_4).

A recovery process that can both remove the cationic contaminants and concentrate the anionic chromate compounds would produce a product that could be utilized as either chromate etchant or strip solution. The product would not be suitable for use as a chromium plating solution because the purity requirements would necessitate further processing to also remove anionic contaminants. It is hoped, therefore, that concentrated chromic acid could be sold to local industry that utilize the treatment system.



*Based on net revenues divided by investment cost (refer to Table 19).

Figure 10. Impact of Quantity of Chromate Waste Material on Recovery System Profitability.

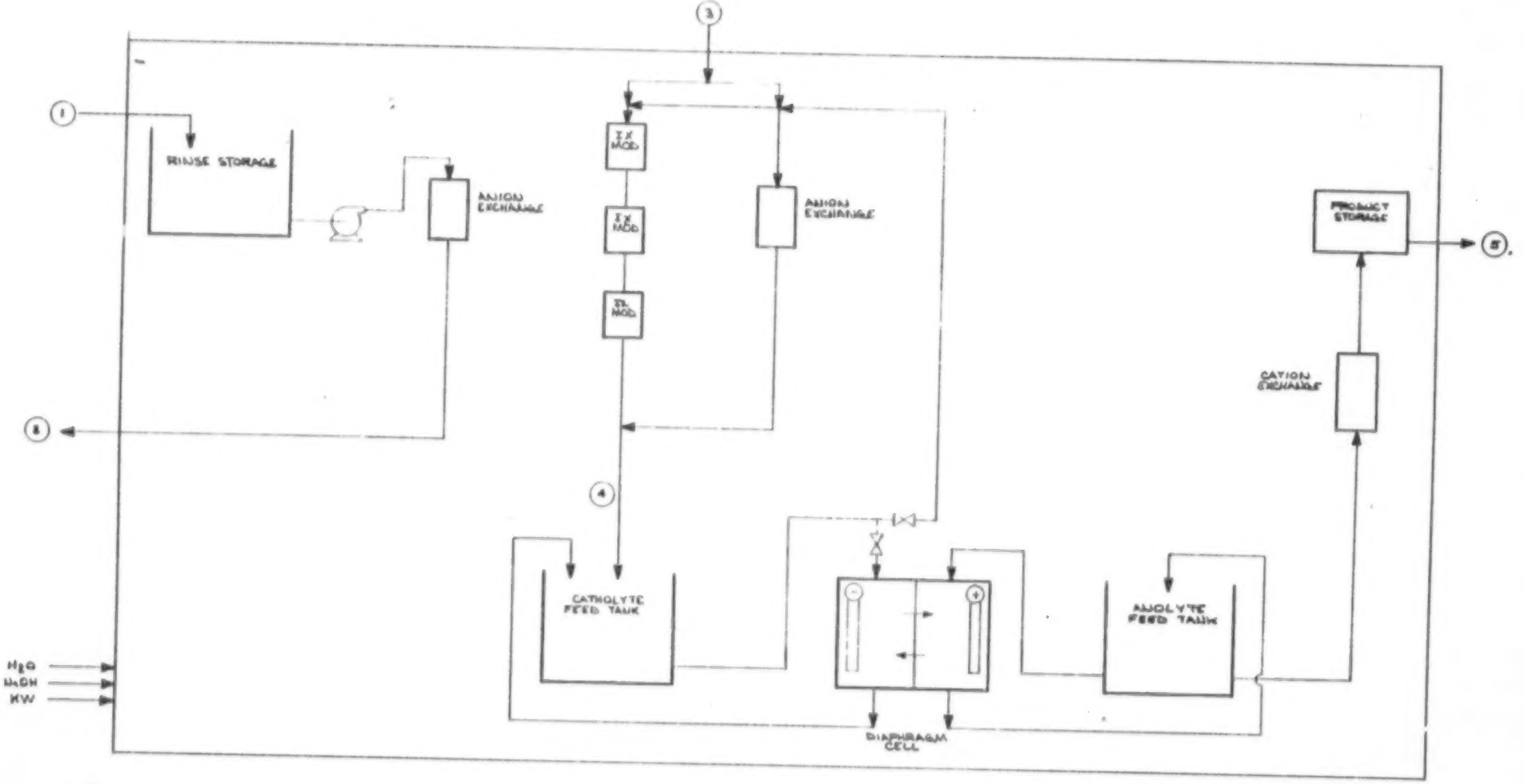
If local industry is reluctant to purchase the chromate solution generated by the recovery process, it could be sold to one of the two firms engaged in chromium refining. Allied Chemical and Diamond Shamrock are the only firms producing chromate products from chromium ore. Both refineries are located on the east coast; Allied Chemical is in Baltimore, Maryland and Diamond Shamrock is in North Carolina. Allied Chemical indicated they would accept concentrated sodium chromate solutions if they were delivered to their Baltimore facility. No firm price was quoted, but it would be less than the current $.60 per pound market price of anhydrous sodium chromate. They indicated they would not accept chromic acid solutions.

Recovery Process

The proposed recovery process is shown in Figure 11. It can accept both concentrated and dilute waste chromate solutions as well as extract and recover the chromate content on ion exchange modules. The process can generate either a concentrated chromic acid or sodium chromate solution.

The process employs two cycles of concentration; ion exchange either in the form of the fixed anion resin columns or the ion exchange modules, separates the chromates from cationic impurities and provides the feed for catholyte compartment of the diaphragm cell. In the diaphragm cell, the chromate concentration is increased in the anolyte up to the required level. The anolyte solution is then purged to the chromate storage tank; if a sodium chromate product is required, the chromic acid must be passed through a cation ion exchange column in the sodium form.

As shown in Figure 11, the fixed anion exchange columns and the ion exchange modules are partially regenerated with dilute chromic acid from the catholyte feed tank. This practice reduces regeneration chemical consumption. In this mode, the catholyte solution is gradually depleted of chromate ions in the diaphragm cell. The catholyte is then enriched by passage through the ion exchange bed and returned to the catholyte feed tank. The enriched solution is circulated through the diaphragm cell which extracts the chromate ions and concentrates them in the anolyte solution. In the diaphragm cell (Figure 12) the anolyte and catholyte are separated by a diaphragm that allows passage of ions by electromigration but prevents the solutions from mixing by diffusion. With the passage of electric current, chromate ions in the catholyte migrate through the diaphragm into the anolyte. The anolyte solution is circulated through the diaphragm cell until it reaches a concentration of 200 to 300 grams per liter of chromic acid.


③
①
RINSE STORAGE
ANION EXCHANGE
IX MOD
IX MOD
IX MOD
ANION EXCHANGE
PRODUCT STORAGE
⑤
CATION EXCHANGE
②
④
CATHOLYTE FEED TANK
ANOLYTE FEED TANK
H₂O
NaOH
KW
DIAPHRAGM CELL

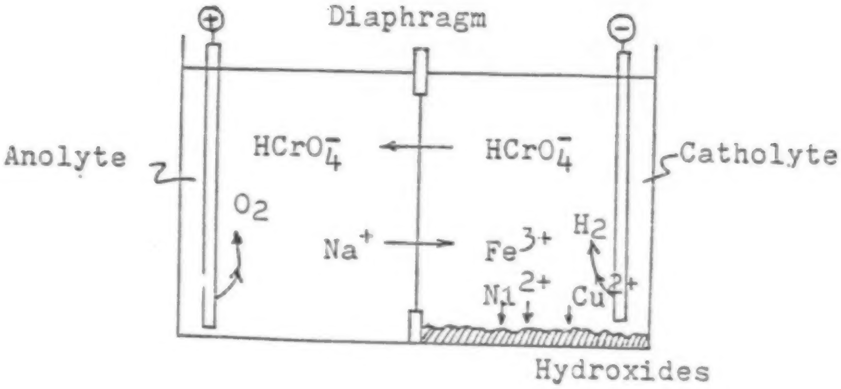
	① CONCENTRATED RINSES			② WASTE WATER		③ IX MODULES		④ CATHOLYTE FEED	⑤ PRODUCT ⚠			UTILITIES		
	gpd	CONCENTRATE (mg Cr/l)	lb Cr/d	gpd	CONCENTRATE (mg Cr/l)	ft³/d	lb Cr/d	CONCENTRATE (gm Cr/l)	gpd	CONCENTRATION gm Na₂CrO₄/l	lb Na₂CrO₄/d	H₂O gpd	NaOH lb/d	ELECTRICITY Kw/d
CASE 1A	236	1175 TO 13545	2.0	4000	< 10	76.0	131.8	20.0	190	250	396	4000	550	
CASE 1B	0	N/A	N/A	4100	< 10	83.6	146.9	20.0	208	250	435	4100	610	
CASE 2A	4367	1175 TO 13545	23.4	13800	< 10	171.0	277.6	20.0	427	250	890	9100	1250	
CASE 2B	0	N/A	N/A	9700	< 10	195.9	318.1	20.0	451	250	941	9700	1320	

NOTES:

⚠ BASED ON 95% RECOVERY.

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)

Figure 11. Chromate recovery system mass balance



Diaphragm
Anolyte
Catholyte
$HCrO_4^-$
$HCrO_4^-$
O_2
Na^+
Fe^{3+}
H_2
Ni^{2+}
Cu^{2+}
Hydroxides

Figure 12. Diaphragm cell for chromic acid recovery.

During regeneration of the ion exchange beds, the beds are first regenerated with catholyte solution. After the catholyte solution removes the bulk of the chromate content from the resin beds, the resin is washed with NaOH and water to complete the regeneration. These regenerants are sent to the rinse storage tank to ensure recovery of the chromate content. All other purge streams in the system are also sent to the rinse storage tank. The combined rinses are then passed through the anion exchange to recover the chromate content before being sent to the waste treatment system.

Recovery Process Material Balance

Four cases have been defined for the quantity of feed solution delivered to the chromate recovery process. They are:

- Case 1A - 30 shops participating; chromate solution and ion exchange modules providing recovery system feed material.
- Case 1B - 30 shops participating; only ion exchange modules providing recovery system feed material.
- Case 2A - All shops participating; chromate solution and ion exchange modules providing recovery system feed.
- Case 2B - All shops participating; only ion exchange modules providing recovery system feed.

Using these four cases, Figure 11 presents the material balance for the recovery system in terms of feed material rate, wastewater requiring treatment, quantity of product and utility consumption. The consumption of NaOH indicated is twice what is required if chromic acid is produced instead of sodium chromate.

Developmental Requirements

Uncertainties associated with the proposed process are as follows:

(1) Durability of anion resin for collection and concentration of chromate ions. Chromate ions are strong oxidizing compounds which have the potential to gradually degrade the physical structure of the resin beds. Highly cross-linked resins should exhibit the longest service life. Resin manufacturers can provide information on type of resin to use and expected service life.[13]

(2) Efficiency of ion exchange regeneration using catholyte solution. The resins selectivity for chromate ions compared to other anions in the catholyte solution will

determine the efficiency of the resin regeneration and the concentration profile of chromate in the catholyte solution. Higher catholyte solution chromate concentrations will yield higher capacity per unit size in the diaphragm cell. This concern is not critical for the feasibility of the proposed process, but will affect the chemical and equipment costs.

(3) Design of the diaphragm cell. A similar component is used in a process recovery system to separate chromate ions from rinse water after chromate process baths (ChromeNapper™). The size of the unit, however, is considerably smaller than what is required for this application. A diaphragm cell is used for chromic acid purification in a similar application at the Chuo Industrial Co-operative in Japan.[14] The success of a diaphragm cell for this type of application has been demonstrated; if commercial units with the required capacity are not mass produced, a more expensive, special order system may be required.

Economic Analysis

The economic incentive to recover a saleable product from the chromate wastes it receives is derived from avoidance of the waste treatment costs and the revenues collected from the sale minus the chemical cost of the recovery process. The following basis will be used for chromate wastes:

a. Treatment cost - \$1.19/lb Cr^{6+}[7,10]

b. Disposal cost - \$.79/lb Cr^{6+} (based on twice
theoretical solids generation, disposal
at 25% solids @ 50c

c. Revenue - Chromic acid product - \$1.11/lb Cr^{6+}
Sodium chromate product - \$.89/lb Cr^{6+}
(based on revenue of 50 percent of market
value after transport cost)

d. Recovery process chemical cost[10] - Chromic Acid
product -
\$.16/lb Cr^{6+}
Sodium Chromate
product -
\$.32/lb Cr^{6+}

e. Net Savings - Chromic Acid product - \$2.93/lb Cr^{6+}
Sodium Chromate product - \$2.55/lb Cr^{6+}

The annual savings for chromic acid or sodium chromate recovery over a range of product rates is presented in Figure 13. The four waste flow cases indicated earlier on page 80 would generate savings ranging from \$85,000 per year to \$143,000 per year.

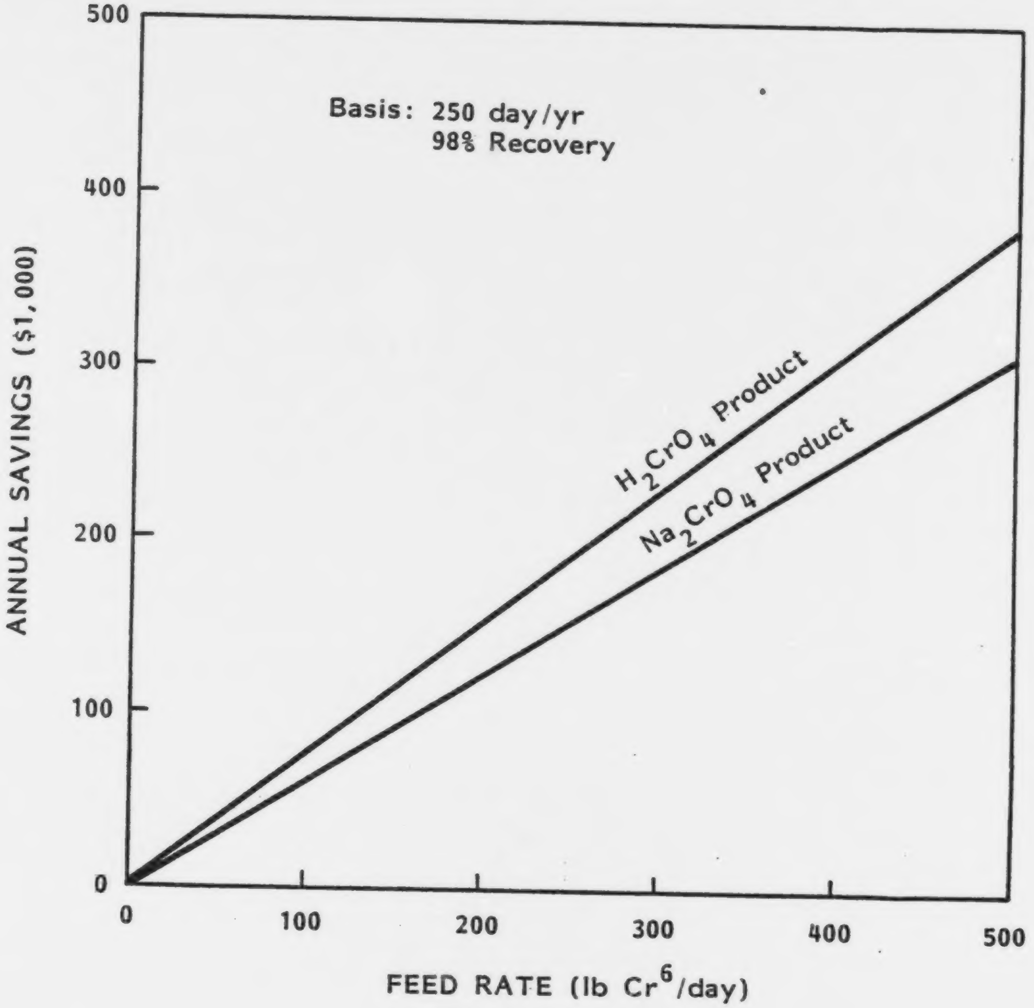


Figure 13. Annual Savings Derived from Chromate Recovery

This savings represents the incentive to build and operate a chromate recovery system. The breakdown of the cost items included in the system cost is presented in Table 20. The total cost is $255,000 for a chromic acid recovery system and $290,000 for a sodium chromate recovery system. The cost includes a reasonable contingency cost (50 percent of process equipment) and design and development costs equal to 20 percent of installed cost. No cost is included for the required building space. The major uncertainty of the estimate is the cost of the diaphragm cell.

The capacity of this system is a function of the anion column and diaphragm cell capacity. The cost of diaphragm cell capacity is not well defined, but it will be assumed that it can process 260 pounds of chromium per 8-hour shift; 130 pounds of capacity is devoted to chromium delivered on ion exchange modules, and 130 pounds is devoted to that extracted from waste chromate solutions.

Using this capacity basis, the annual cost basis is presented for the chromium recovery process operating one or two shifts per day in Table 21. The analysis shows that if sufficient feed material were available to occupy the process capacity for only one shift per day, 260 lb of hexavalent chromium, the plant has a reasonable return on investment. At two shifts per day operation (520 lb of hexavalent chromium) the system is highly profitable with a pre-tax return on investment of 138 percent.

For the four cases of feed to the system identified on page 99 the pre-tax return on investment are as follows for chromic acid recovery:

Case 1A - 17 percent

Case 1B - 21 percent

Case 2A - 63 percent

Case 2B - 70 percent

As shown, with complete participation of the plating industry, or with partial participation and augmenting the feed with wastes from other industries, the project is economically viable.

COPPER RECOVERY SYSTEM

Copper is plated on metals from both acid and cyanide plating solutions. The primary source of copper wastes is the copper lost to the rinses following these plating processes. In

TABLE 20. CHROMATE RECOVERY SYSTEM COST

	($)
A. Chromic Acid Product	
1. Process Equipment (Installed Cost)	
a. 2 Bed Anion Exchanger @ 20ft^3 with automated regeneration	$ 33,000
b. Tanks:	
Rinse Storage @10,000 gal	10,500
Catholyte Feed @5,000 gal	7,000
Anolyte Feed @2,000 gal	4,000
Product Storage @7,000 gal	8,500
c. Diaphragm Cell (estimate, no quotes obtained)	50,000
d. Pumps (4 required each with spare, low capacity)	12,000
e. Piping Instrumentation Reagent Supply (20 percent of process equipment)	25,000
f. Contingency (50 percent of process equipment)	63,000
g. Building Space	ND
Total Installed Cost	$213,000
Development and Design (20 percent of installed cost)	$ 43,000
Total Cost	$256,000
B. Sodium Chromate Product	
H 1 Bed Cation Exchange Column @ 20ft^3, manual regeneration	$12,000
G Added Contingency	23,000
Total Cost	$291,000

ND = Not Determined

TABLE 21. CADMIUM RECOVERY SYSTEM

Process Equipment (Installed Cost)	
A. Electrolytic Reactor 60 ft^2 cathode area)	$ 40,000
B. Tanks:	
Reactor Feed Tank @ 5,000 gal	7,000
CN Recovery @ 2,000 gal	4,000
NaCN Storage @ 2,000 gal	4,000
C. HCN Scrubber	5,000
D. Pumps (3 required, each with spare, low capacity)	9,000
Process Equipment Total	$ 69,000
E. Piping, Instrumentation and Reagent Supply (20% of process equipment)	14,000
F. Contingency (25% of process equipment)	17,000
G. Building Space	ND
Total Installed Cost	$100,000
Development and Design (20% of Installed Cost)	20,000
Total Cost	$120,000

ND = Not Determined

TABLE 21. (Continued)

Investment Cost	$255,000
Annual Costs	($/yr)
1. Depreciation	25,500
2. Maintenance	15,000
3. Labor (4 hrs per shift @$15/hr)	
1 shift/day	15,000
2 shifts/day	30,000
Revenues (260 lb/shift)	($/yr)
1 shift/day	$212,000
2 shifts/day	$424,000
Net Revenues	
1 shift/day	156,000
2 shifts/day	353,000
Pre-Tax ROI	
1 shift/day	61%
2 shifts/day	138%

the Cleveland area, the vast majority of copper plating operations utilize cyanide baths.

The copper can be reclaimed as a saleable product by plating it out of solution in an electrochemical reactor. The reactor would produce a metallic copper strip which could be sold to a copper refiner for a relatively high percentage of its original cost.[15] The market for such recovered metal is well established.

Electrochemical recovery of copper from solution has been demonstrated in both plating chemical recovery and copper refining operations. Package systems specifically for this purpose are commercially available.[16]

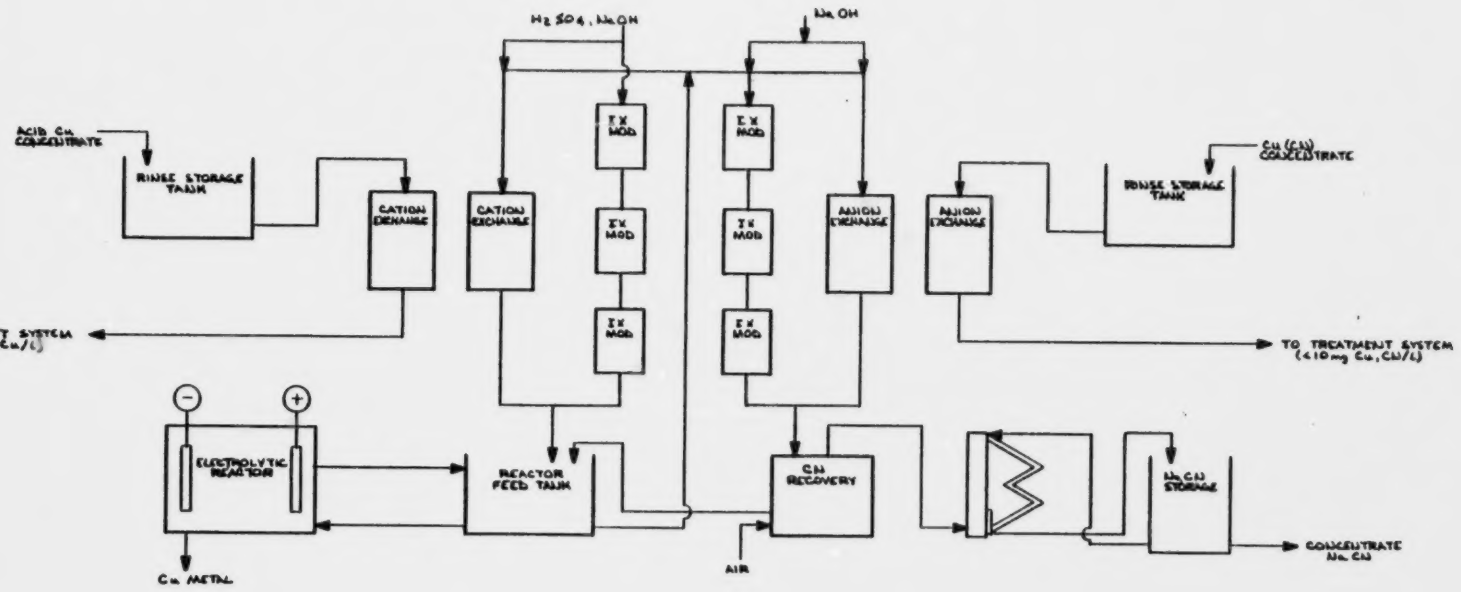
Process Description

The required size of the electrochemical reactor for plating out the copper from solution is strongly influenced by the concentration of copper in the reactor feed solution. Although recovery has been demonstrated at concentrations as low as 5,000 mg Cu/liter, operation at this concentration requires high agitation rates and elevated temperatures in the reactor and still yields a low removal rate in terms of pounds of copper extracted per square foot of cathode area.[15,16]

The proposed recovery process is shown in Figure 14. It can accept copper cyanide or acidic copper wastes in the form of concentrated rinses or ion exchange modules.

To yield a more efficient system, the copper feed is preconcentrated by ion exchange before entering the reactor. Cyanide solutions are concentrated on anion resins and acidic copper is concentrated on cation resins. Both column systems are regenerated with the acidic (5-10% H_2SO_4) electrolytic mother liquor. In practice, this arrangement is chemically efficient. Hydrogen ions generated at the anode in the electrochemical reactor are exchanged for copper ions in the cation column regeneration. In the anion column regeneration, hydrogen ions combine with the cyanide ions to form hydrogen cyanide. The net result is a balanced system; the acid concentration in the electrolytic mother liquor should stay fairly constant.

Regeneration of the anion exchange resins with acid is required to elute the tightly bound cyanide ions from the resin. The cyanide combines with the hydrogen to form HCN; the HCN is removed from the regenerant by bubbling air through it and passing the gas through a sodium hydroxide solution.[10] This should yield a saleable sodium cyanide solution.


ACID Cu CONCENTRATE
RINSE STORAGE TANK
CATION EXCHANGE
TO TREATMENT SYSTEM (<10 mg Cu/l)
H2SO4, NaOH
CATION EXCHANGE
IX MOD
IX MOD
IX MOD
NaOH
IX MOD
IX MOD
IX MOD
ANION EXCHANGE
ANION EXCHANGE
RINSE STORAGE TANK
Cu(CN) CONCENTRATE
TO TREATMENT SYSTEM (<10 mg Cu,CN/l)
−
+
ELECTROLYTIC REACTOR
Cu METAL
REACTOR FEED TANK
CN RECOVERY
AIR
NaCN STORAGE
CONCENTRATE NaCN

(To provide the reader with
complete information, this
reduced schematic drawing is
included in the report.
This is the best copy available; we regret that portions
are undecipherable.)

Figure 14. Copper Recovery System

The use of acidic electrolytic mother liquor for anion column regeneration yields a high copper content, which is important for operation of the electrochemical reactor. The sulfate content of this stream elutes the copper cyanide complexes from the resin but the cationic copper in the regenerant solution does not compete for the resin sites. Consequently, regeneration efficiency is independent of the acid's copper concentration.

To achieve maximum copper concentration in the fixed cation column regenerant, a weak acid resin is utilized.[10] A strong acid resin is used in the ion exchange modules for acid copper rinses because the resin is operable at low feed solution pH.[10]

Recovery Process Material Balance

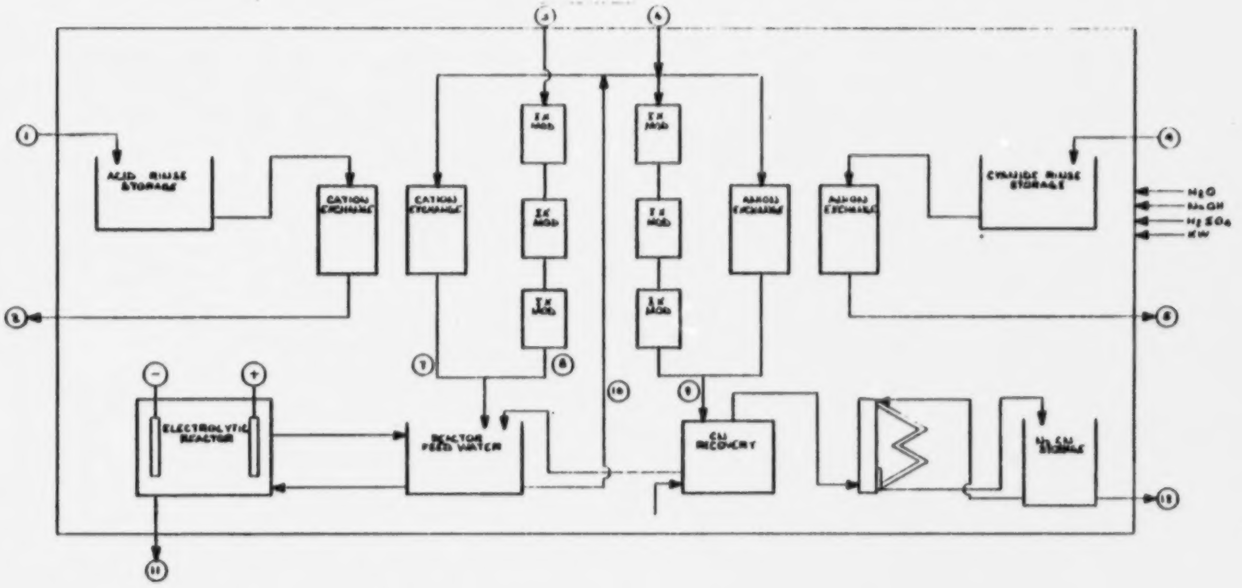
Four cases have been defined for the quantity of feed solution delivered to the copper recovery process. They are:

- Case 1A - 30 shops participating; copper solutions and ion exchange modules provide the recovery system feed material.
- Case 1B - 30 shops participating; only ion exchange modules provide the recovery system feed material.
- Case 2A - All Cleveland shops participating; copper solutions and ion exchange modules provide the recovery system feed material.
- Case 2B - All Cleveland shops participating; only ion exchange modules provide the recovery system feed.

Using these four cases, Figure 15 presents the material balance for the recovery process in terms of feed material rate, wastewater requiring treatment, quantity of product (NaCN and copper) and utility consumption.

As shown, the product rates for all four cases are extremely low and would not come close to generating sufficient revenue to justify even moderate investment in recovery systems.

A simpler recovery system may be warranted in this case. The simpler system proposed would limit recovery to ion exchange modules used for copper rinses. The portion of the recovery system still required is shown in Figure 16. The system consists of a module regenerating facility, the CN recovery system and the electrolytic reactor and reactor feed tanks. The portion of the regenerant that is high in copper concentration is kept in the recovery loop, all other streams are sent to the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ACID RINSE STORAGE
CATION EXCHANGE
CATION EXCHANGE
IX MOD
IX MOD
IX MOD
IX MOD
IX MOD
IX MOD
ANION EXCHANGE
ANION EXCHANGE
CYANIDE RINSE STORAGE
H2O
NaOH
H2SO4
KW
ELECTROLYTIC REACTOR
−
+
REACTOR FEED WATER
CU RECOVERY
NaCN STORAGE

	① △ CONCENTRATED ACID RINSE			② WASTE WATER		③ △ CATION IX MOD		④ CONCENTRATE CN RINSE			⑤ WASTE WATER		⑥ ANION IX MOD		⑦ WEAK ACID REGENERANT	⑧ STRONG ACID REGENERANT
	gpd	CONCENTRATE (mg Cu/l)	lb Cu/d	gpd	CONCENTRATION (mg Cu/l)	ft³/d	lb Cu/d	gpd	CONCENTRATION (mg Cu/l)	lb Cu/d	gpd	CONCENTRATION (mg Cu/l)	ft³/d	lb Cu/d	mg Cu/l	mg Cu/l
CASE 1A	0	-	-	950	410	0	-	2440	708	14.4	2440	410	7.7		25600	14300
CASE 1B	0	-	-	880	410	0	-	0	-	-	0	-	19.6		25600	14300
CASE 2A	0	-	-	1110	410	0	-	2517	784	15.2	2517	410	11.8		25600	14300
CASE 2B	0	-	-	1088	410	0	-	0	-	-	0	-	24.3		25600	14300

	⑨ ANION REGENERANT	⑩ △ ELECTROLYTIC SOLUTION	⑪ △ Cu METAL PRODUCT	⑫ △ NaCN PRODUCT		UTILITIES			
	mg Cu/l	mg Cu/l	lb Cu/d	CONCENTRATION gm NaCN/l	gpd	H2O gpd	NaOH lb/d	H2SO4 lb/d	KW
CASE 1A	20700	15000	21.7	200	7.0	950	62	0	
CASE 1B	20700	15000	20.0	200	6.5	880	57	0	
CASE 2A	20700	15000	24.1	200	8.5	1110	74	0	
CASE 2B	20700	15000	24.7	200	8.0	1085	70	0	

NOTES:

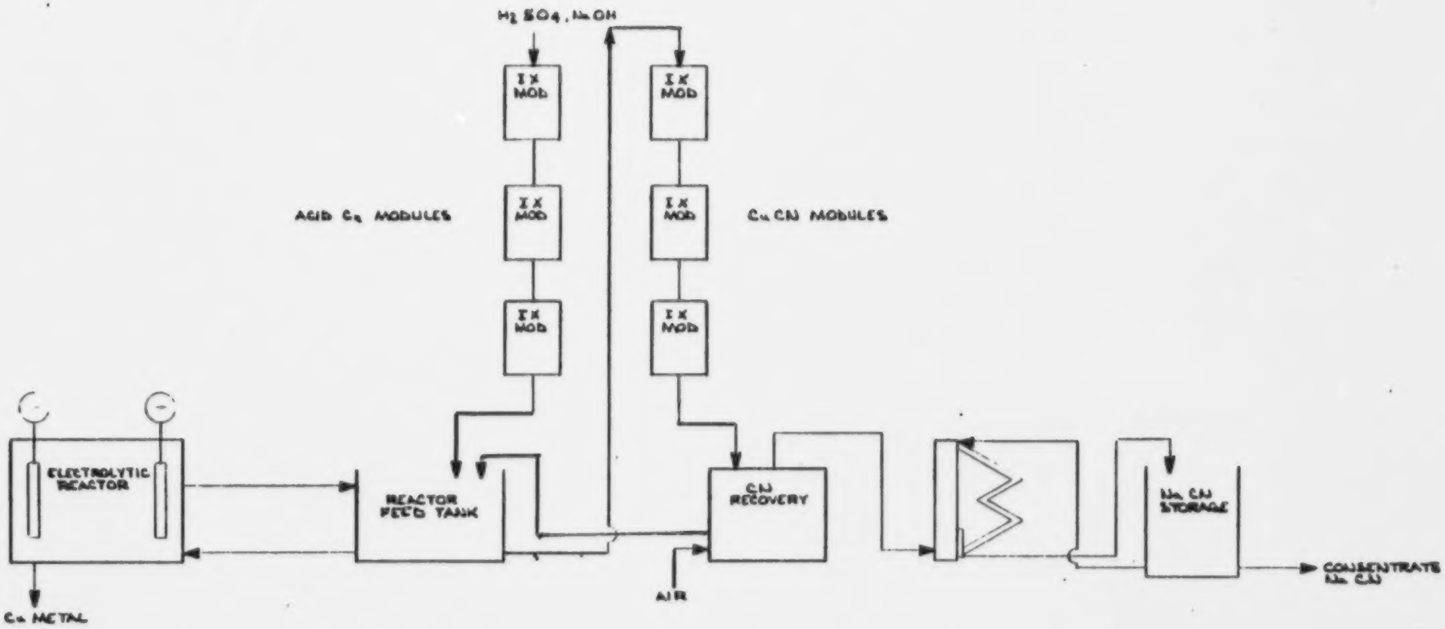
△1 BECAUSE OF THE PREDOMINANCE OF CuCN PLATING, ALL WASTES ARE ASSUMED TO BE FROM PLATING.

△2 BASED ON 95% RECOVERY.

△3 MINIMUM CONCENTRATION.

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)

Figure 15. Copper Recovery Mass Balance


H2 SO4, NaOH
IX MOD
IX MOD
IX MOD
IX MOD
IX MOD
IX MOD
ACID Cu MODULES
Cu CN MODULES
ELECTROLYTIC REACTOR
REACTOR FEED TANK
CN RECOVERY
AIR
Na CN STORAGE
CONCENTRATE Na CN
Cu METAL

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)

Figure 16. Simplified copper recovery

treatment network. Recovery efficiency would be approximately 75 percent of the copper contained on the resin. Volume build-up in the system would be controlled by surface evaporation from the electrolytic mother liquor; it would be maintained at approximately 150°F. A mass balance is presented for this process for cases 1B and 2B in Figure 17.

Probably a portion of the electrolytic mother liquor would have to be purged from the system on a regular basis to control the build-up of dissolved solids that were contained in the ion exchange regenerant solutions. In the more comprehensive system shown in Figure 14, this build-up was controlled by the weak acid ion exchange column that separated copper ions from other ions dissolved in the wastewater. The copper loss associated with the purge could be minimized by running the reactor over the weekend and purging the solution when copper content was at a minimum.

Developmental Requirements

Electrolyte extraction of copper from acidic solutions onto stainless steel cathodes is a well established commercial process. The fact that copper is more noble than most other common plating materials should assure a good cathode current efficiency in the process.

An area that should be investigated is the efficiency of the anion resin regeneration as a function of regenerant copper concentration. Design parameters for the cyanide recovery portion of the process also must be determined.

Economic Analysis

As with chromate recovery, the economic benefit derived from copper recovery is based on the revenues generated by the sale of the products and avoidance of the costs involved for wastewater treatment and solid waste disposal. The following basis will be used for copper wastes:

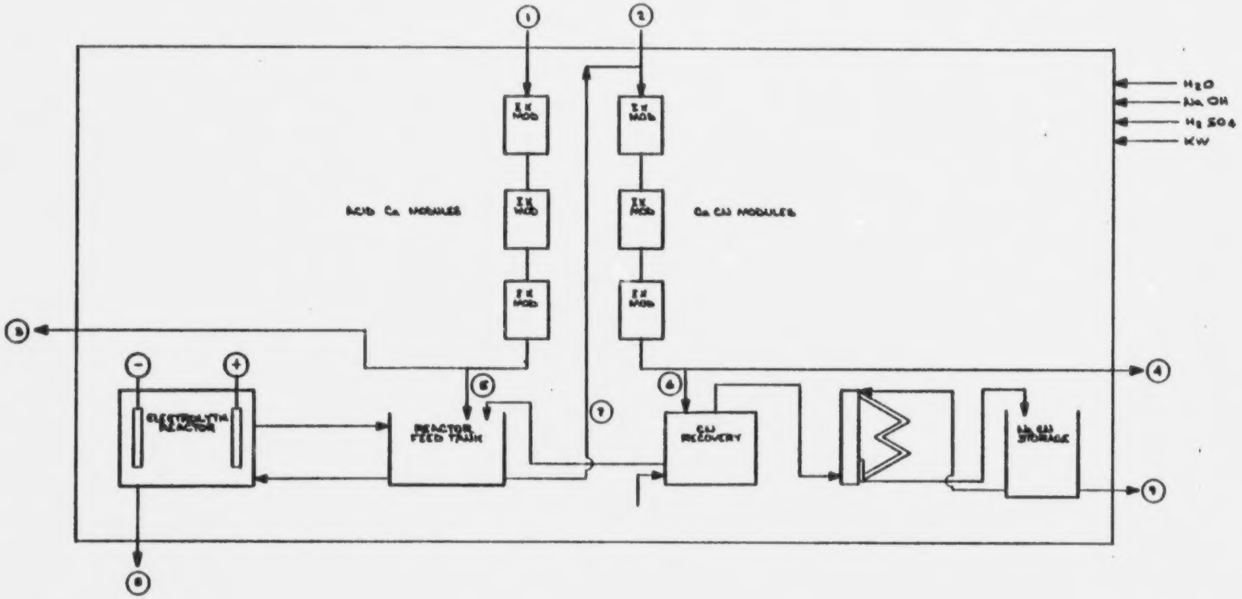
Copper Cyanide - based on 75 percent recovery of feed copper and cyanide, all values based on amount of copper in feed.

(a) Treatment cost - \$1.35/lb Cu[7] (cyanide oxidation and metal precipitation)

(b) Disposal cost - \$.46/lb Cu (based on twice theoretical solids generation; disposal at 25 percent solids @ 50¢ per gallon)

(c) Revenue - \$.63/lb Cu (based on 75 percent of market value of copper and sodium cyanide)

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)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④
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⑥
⑦
⑧
⑨
H2O
NaOH
H2SO4
KW
IX MOD
ACID Cu MODULES
Cu CN MODULES
−
+
ELECTROLYTIC REACTOR
REACTOR FEED TANK
CN RECOVERY
NaCN STORAGE

	① △1 ACID Cu IX MOD.		② Cu CN IX MOD.		③ ACID WASTE WATER		④ CYANIDE WASTE WATER			⑤ ACID REGENERANT (mg Cu/l)	⑥ CN REGENERANT (mg Cu/l)	⑦ △2 ELECTROLYTIC SOLUTION (mg Cu/l)	⑧ △3 Cu METAL PRODUCT (lb Cu/d)	⑨ △2 NaCN PRODUCT	
	ft³/d	lb Cu/d	ft³/d	lb Cu/l	gpd	CONCENTRATED (mg Cu/l)	gpd	CONCENTRATED (mg Cu/l)	mg CN/l					CONCENTRATE (gm NaCN/l)	gpd
CASE 1B	0	-	19.6	21.0	0	-	810	780	400	11800	18600	10000	15.8	200	4.9
CASE 2B	0	-	24.3	26.0	0	-	1000	780	400	11800	18600	10000	19.5	200	6.3

	UTILITIES			
	H2O gpd	NaOH lb/d	H2SO4 lb/d	KW
CASE 1B	810	84	0	
CASE 2B	1000	104	0	

NOTES:

△1 BECAUSE OF THE PREDOMINANCE OF Cu CN PLATING, ALL WASTES ARE ASSUMED TO BE FROM CN PLATING.

△2 MINIMUM CONCENTRATE.

△3 BASED ON 75% RECOVERY.

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Figure 17. Copper recovery system mass balance

(d) Recovery process chemical cost - $.15/lb Cu

(e) Net savings - $2.29/lb Cu

The net savings is based on the amount of copper in the recovery system feed. The savings per pound of copper recovered (assuming the same recovery efficiency for cyanide) is $3.05 per pound of copper. It is significant that of the recovery savings, $1.36 (of the $2.29/lb of Cu) is derived from avoiding the need to treat the cyanides.

A similar basis for acidic copper recovery is as follows:

Acid Copper - based on 75 percent recovery of copper feed; all values based on amount of copper in feed.

(a) Treatment cost[7] - $.12/lb Cu

(b) Disposal cost - $.46/lb Cu

(c) Revenue - $.42/lb Cu

(d) Recovery chemical cost - $.10/lb Cu

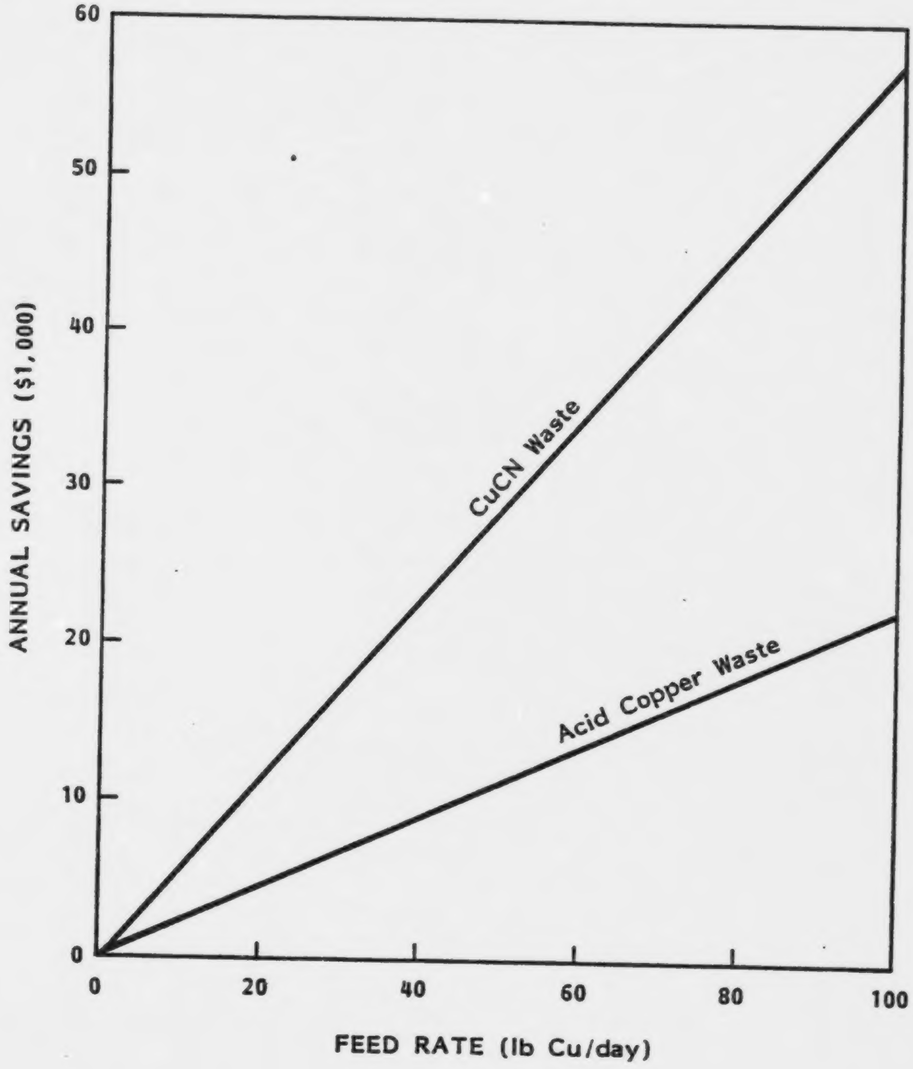
(e) Net savings - $.90/lb Cu

Again the savings are based on the amount of copper in the feed. The savings per pound of copper recovered would equal $1.20 per pound of copper.

Using these savings as a basis, the annual savings generated by copper recovery are presented as a function of the amount fed to the recovery process in Figure 18. The two applicable waste flow cases (1B and 2B), defined on page 89, would generate revenues of $12,000 and $15,700 per year respectively.

The savings represent the incentive to build and operate a copper recovery system. The breakdown of the cost items included in the cost of the system is presented in Table 22. The cost is for the simpler system shown in Figure 16. With a capacity of 100 pounds per day of copper wastes either in the form of copper cyanide or acid copper wastes. The total cost of the system is $120,000. The contingency for this system was set at 25 percent of the process equipment cost as all costs and process parameters are well defined.

The limiting factor in the recovery process capacity is the electrolytic reactor, which is assumed to operate continuously 24 hours per day. The balance of the plant would only need to operate one shift per day.



Note: Operating cost of recovery system not included in analysis.

Figure 18. Annual Savings Derived from Copper Recovery

TABLE 22. COPPER RECOVERY SYSTEM

Process Equipment (Installed Cost)		
A.	Electrolytic Reactor 60 ft^2 cathode area)	$ 40,000
B.	Tanks:	
	Reactor Feed Tank @ 5,000 gal	7,000
	CN Recovery @ 2,000 gal	4,000
	NaCN Storage @ 2,000 gal	4,000
C.	HCN Scrubber	5,000
D.	Pumps (3 required, each with spare, low capacity)	9,000
Process Equipment Total		$ 69,000
E.	Piping, Instrumentation and Reagent Supply (20% of process equipment)	14,000
F.	Contingency (25% of process equipment)	17,000
G.	Building Space	ND
Total Installed Cost		$100,000
Development and Design (20% of Installed Cost)		20,000
Total Cost		$120,000

ND = Not Determined

Using this operating basis, the annual cost of the recovery system is presented in Table 23. Even at full capacity, the system does not generate significant return for capital invested. Two cases of waste flows would lose money; Case 1B would lose $22,000 per year and Case 2B would lose $19,000 per year.

ZINC RECOVERY SYSTEM

Zinc plating has many parallels with copper plating; the major source of zinc wastes are the rinses following zinc plating processes, zinc is plated both from cyanide and non-cyanide (chloride) baths and zinc can be recovered by electrolytic recovery from acid solutions.

The incentive to recover zinc is lessened because it is a relatively inexpensive metal; however, the waste survey indicated that it is present in the waste in larger amounts than other metals. A major portion of the benefit derived from zinc recovery stems from avoidance of the cyanide oxidation cost; to avoid this cost, a market must be established for the NaCN generated by the process.

Recovery Process

Unlike copper, which can be electrochemically removed from solution with high current efficiencies and little concern about solution impurities, electrochemical recovery of zinc is a more troublesome operation. Reasonable recovery rates and acceptable cathode efficiencies can be fostered by maintaining the electrolytic solution at greater than 20,000 mg/l of zinc. Potential problems with solution impurities could be identified and possibly resolved during pilot evaluations.

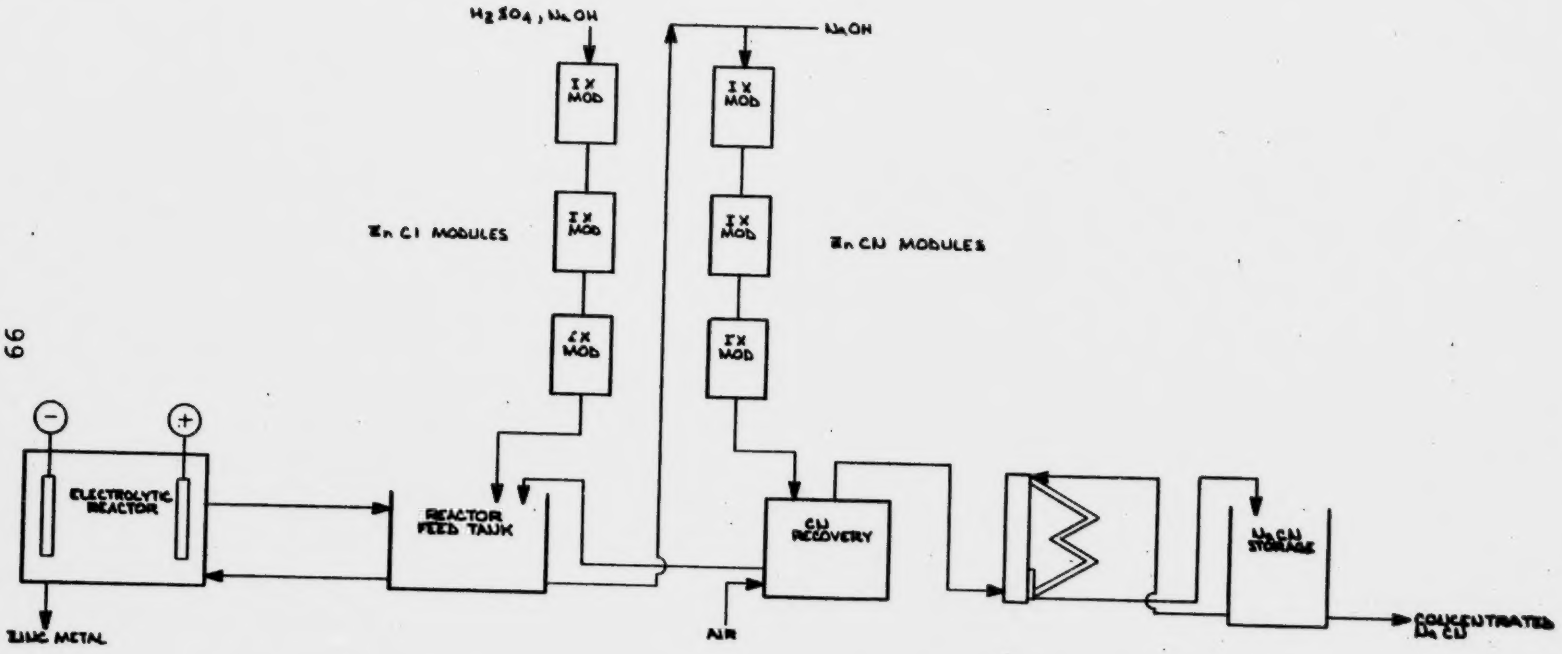
Zinc is a fairly inexpensive metal and the main benefit of the recovery would be avoidance of the treatment and disposal costs. The major component of the treatment cost is the chemical cost of cyanide oxidation. The recovery process avoids the cost of cyanide oxidation by generating a sodium cyanide (NaCN) byproduct. If this byproduct could not be marketed, it would have to be treated.

The proposed recovery process is shown in Figure 19. The process is the same as the simplified copper recovery process. The system can handle zinc chloride or zinc cyanide wastes concentrated on ion exchange resin modules.

It is possible to recover the zinc contained in concentrates with this system by pumping the solution through the modules. This possibility will not be included in the analysis, however, because it is not known whether the module handling apparatus would have excess capacity to provide any

TABLE 23. ANNUAL COST OF COPPER RECOVERY SYSTEM

Investment Cost	$120,000
Annual Costs	($/yr)
Depreciation	12,000
Maintenance	7,200
Labor (4 hrs/shift, 1 shift/day, @$15/hr)	15,000
Annual Total Cost	$ 34,200
Revenues (100 lb Cu/day)	
A. All CuCN	57,500
B. 50% CuCN, 50% Acid Cu	40,000
Net Revenues	
A. All CuCN	23,300
B. 50% CuCN, 50% Acid Cu	5,800
Simple Pre-tax ROI	
A. All CuCN	19%
B. 50% CuCN, 50% Acid Cu	5%


H2SO4, NaOH
NaOH
IX MOD
IX MOD
IX MOD
IX MOD
IX MOD
IX MOD
Zn Cl MODULES
Zn CN MODULES
ELECTROLYTIC REACTOR
REACTOR FEED TANK
CN RECOVERY
NaCN STORAGE
ZINC METAL
AIR
CONCENTRATED NaCN

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)

Figure 19. Zinc recovery process

capabilities other than regeneration of delivered modules. However, it is a possibility.

Recovery Process Mass Balance

Four cases have been identified for the quantity of feed solution delivered to the zinc recovery process. They are:

- Case 1A - 30 shops participating; wastes are delivered as zinc solutions and ion exchange modules
- Case 1B - 30 shops participating; all wastes are concentrated on ion exchange modules before shipment to recovery facility
- Case 2A - All Cleveland shops participating; wastes are delivered as zinc solutions and ion exchange modules
- Case 2B - All Cleveland shops participating; all wastes are concentrated on ion exchange modules before shipment to the recovery facility

Using these four cases, Figure 20 presents the material balance for the recovery process in terms of feed rate, wastewater requiring treatment, quantity of products (NaCN and zinc) and utility consumption. The balance only considers the wastes that are concentrated on ion exchange resins as recovery feed material. All concentrates are treated in the waste treatment system.

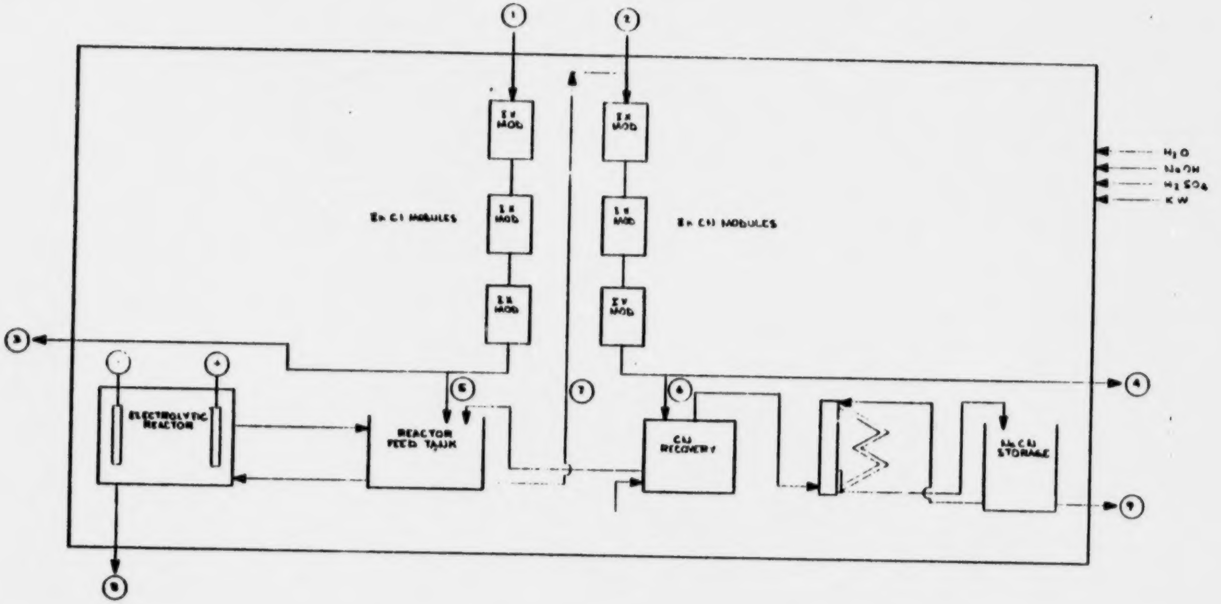
Developmental Requirements

The major uncertainty associated with the process is the efficiency of electrolytic recovery at concentrations of 20 to 30 g of zinc per liter and the influence of low concentrations of more noble metals such as copper. Pilot data needs to be generated regarding reaction rates for sizing the electrolytic reactor.

Other areas which require investigation are the efficiency of the anion columns regeneration using an acid solution rich in zinc and design parameters for the cyanide recovery system.

Economic Analysis

The economic benefit of zinc recovery is based on the revenues obtained from sale of the recovered zinc and sodium cyanide and on the avoidance of the costs associated with treatment of these pollutants and disposal of the solid waste. The following basis will be used to calculate the economic benefits of the zinc recovery system: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IX MOD
ZnCl MODULES
ZnCN MODULES
ELECTROLYTIC REACTOR
REACTOR FEED TANK
CN RECOVERY
NaCN STORAGE
H_2O
NaOH
H_2SO_4
KW

	① ZINC Cl IX MODULES ⚠1		② Zn CN IX MODULES ⚠2		③ ZnCl WASTE WATER		④ Zn CN WASTE WATER			⑤ ACID REGENERATE	⑥ CN REGENERATE	⑦ ELECTROLYTIC SOLUTION ⚠3	⑧ Zn METAL PRODUCT ⚠1	⑨ Na CN PRODUCT ⚠4		UTILITIES			
	ft^3/d	lb Zn/d	ft^3/d	lb Zn/d	gpd	Mg Zn/l	gpd	Mg Zn/l	Mg CN/l	Mg Zn/l	Mg Zn/l	Mg Zn/l	lb Zn/d	CONCENTRATE (g/l)	gpd	H_2O gpd	Na OH lb/d	H_2SO_4 lb/d	KW
CASE 1A	0	–	4.5	4.4	0	–	185	710	1030	12300	27800	20000	3.3	200	5.4	185	20	0	
CASE 1B	39	78.7	325	315	1600	1470	12370	710	1030	12300	27800	20000	295	200	380	15000	1560	238	
CASE 2A	18	37.3	154	149	740	1470	6240	710	1030	12300	27800	20000	140	200	180	70800	740	110	
CASE 2B	56	115.1	475	432	2300	1470	18370	710	1030	12300	27800	20000	432	200	570	20700	2300	342	

NOTES:

⚠1 ESTIMATED AT 50% OF TOTAL ZINC.

⚠2 ESTIMATED AT 80% OF TOTAL ZINC.

⚠3 MINIMUM CONCENTRATION.

⚠4 BASED ON 75% RECOVERY.

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)

Figure 20. Zinc recovery mass balance

Zinc Cyanide - Based on 75 percent recovery of zinc and cyanide contained in feed, all values based on amount of zinc in feed.

(a) Treatment cost[7] - $1.42/lb Zn (This is based on using Cl_2 and NaOH for CN oxidation; the cost is $3.36/lb Zn if NaOCl is used)

(b) Disposal cost - $.46/lb Zn (based on twice theoretical solids generation; disposal at 25 percent solids @ $.50 per gallon)

(c) Revenue - $.73/lb Zn (based on 75 percent of market value for Zn and NaCN)

(d) Recovery process chemical cost - $.43/lb Zn

(e) Net savings - $2.18/lb Zn (if NaOCl is used for oxidation, net becomes $4.12/lb Zn)

The amount of savings is based on the amount of zinc in the recovery system feed. The savings per pound of zinc recovered is $2.91/lb. It is significant that of the $2.18 savings, $1.73 is related to avoidance of the cost for chemical oxidation of the cyanides and sale of the recovered sodium cyanide. This underscores the need to have a market for the NaCN to achieve the potential savings.

Zinc Chloride - Same basis as zinc cyanide.

(a) Treatment[7] - $.12/lb Zn

(b) Disposal - $.46/lb Zn

(c) Revenue - $.30/lb zn

(d) Recovery process chemical cost - $.11/lb Zn

(e) Net savings - $.77/lb Zn

The savings are $1.02 per pound of zinc recovered.

Using these savings as a basis, the annual savings realized by zinc recovery are shown in Figure 21 as a function of the amount of zinc fed to the recovery process. Using this cost formula, the annual savings for the four waste flow cases are:

- Case 1A - $2,400
- Case 1B - $187,000

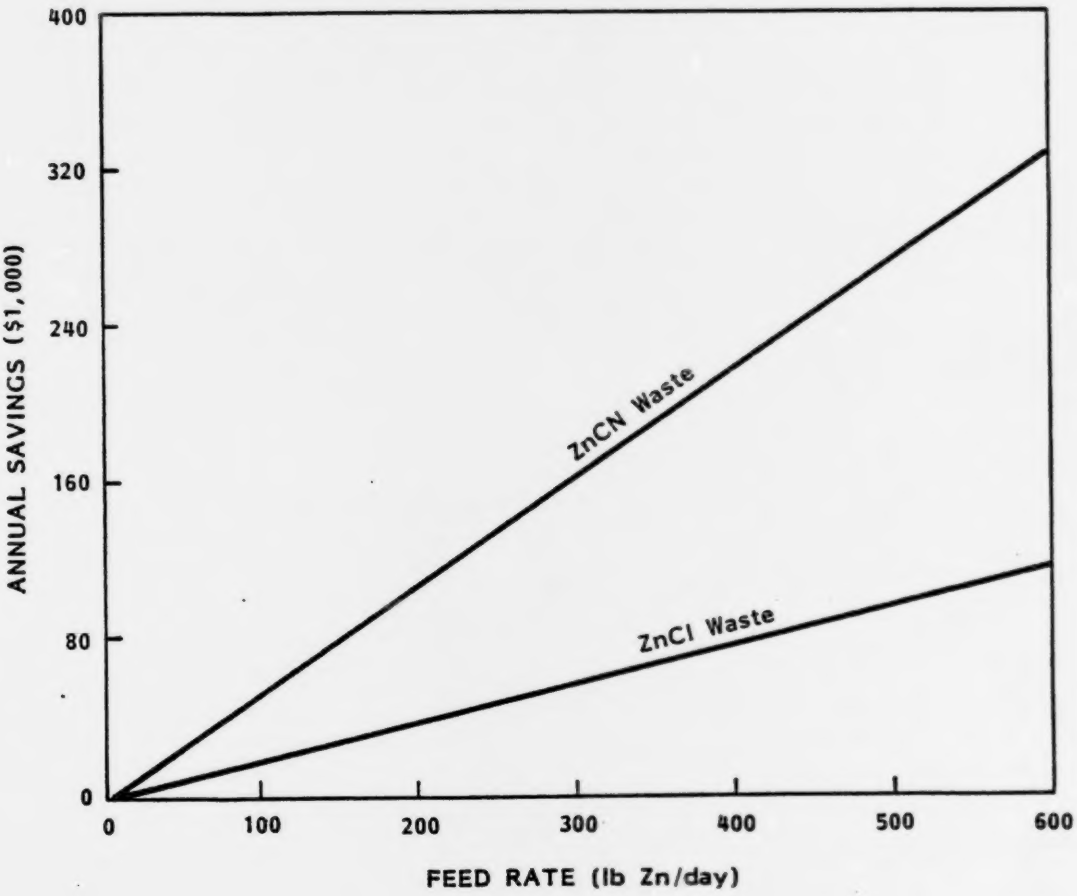


Figure 21. Annual Savings Derived from Zinc Recovery

- Case 2A - $88,000
- Case 2B - $258,000

The savings represent the incentive to build and operate a zinc recovery system. The breakdown of the cost items included in the system are presented in Table 24. The cost in Table 24 is for a system with a recovery capacity of 500 lb of zinc per day in the system feed. The cost for this system is $430,000. The major cost items are the electrolytic reactors (3 @ $55,000) and the contingency used ($105,000). By going to a single large reactor and eliminating the uncertainties about the design (the basis for the contingency), a significant reduction in the estimated cost could be achieved.

The cost for a system with a feed rate of 100 pounds of zinc per day would be $140,000 using the same basis as in Table 24.

The annual costs of the recovery system are presented in Table 25. The estimate is based on operating the plant 8 hours per day, although the electrochemical reactor would operate continuously.

As the Table indicates, reasonable return on investment is realized if the plant produces zinc cyanide wastes. The simple pre-tax ROI for the four waste flow cases are as follows:

- Case 1A - No return
- Case 1B - 16%
- Case 2A - No return
- Case 2B - 33%

CADMIUM RECOVERY SYSTEM

The major sources of cadmium wastes are the rinse solutions following cadmium cyanide plating baths.[17] The cadmium contained in the rinse water can be concentrated on ion exchange resins and shipped to the central treatment facility. The resin modules can then be regenerated at the treatment facility and returned to the plating shops. The regenerant solutions contianing the cadmium would provide the feed material for the recovery process.

Recovery Process

The recovery process proposed for cadmium recovery is essentially the same as the one utilized for copper and zinc recovery. The process produces a cadmium metal and con-

TABLE 24. COST OF ZINC RECOVERY SYSTEM
(500 lb Zn/d in feed)

Process Equipment		
A.	Electrolytic reactors (3 @ 100 ft^2 cathode area)	$165,000
B.	Tanks	
	Reactor Feed Tank @ 10,000 gal	10,000
	CN Recovery Tank @ 5,000 gal	7,000
	NaCN Storage @ 5,000 gal	7,000
C.	HCN Scrubber	10,000
D.	Pumps (3 required, each with spare)	12,000
Process Equipment Total		$211,000
E.	Piping, Instrumentation, and Reagent Supply System (20% of process equipment)	42,000
F.	Contingency (50% of process equipment)	105,000
G.	Building Space	ND
Total Installed Cost		$358,000
Developmental Design (20% of Installed Cost)		72,000
Total Cost		$430,000

ND = Not Determined

TABLE 25. ANNUAL COST OF ZINC RECOVERY SYSTEM

Investment Cost	$430,000
Annual Costs	($/yr)
Depreciation	43,000
Maintenance	26,000
Labor (12 hrs/shift @ $15/hr)	45,000
Total Annual Cost	$114,000
Revenues (500 lb/d)	
A. All ZnCN	275,000
B. 50% ZnCN, 50% ZnCl	188,000
Net Revenues	
A. All ZnCN	161,000
B. 50% ZnCN, 50% ZnCl	74,000
Simple Pre-tax ROI	
A. All ZnCN	37%
B. 50% ZnCN, 50% ZnCl	17%

centrated sodium cyanide solution as products. The major components of the system are shown in Figure 22. The cadmium cyanide complexes are eluted from the resin modules by the recirculated electrolytic mother liquor; the cyanide content is removed from the solution by bubbling air into it; the air is scrubbed by NaOH solution to reclaim the cyanide as NaCN.[10] The cadmium solution is then sent to an electrochemical cell where cadmium is plated out on the cathodes. The use of the electrolytic solution to regenerate the ion exchange resins should enable the reactor cadmium concentration to be maintained in the 30,000 to 40,000 mg/liter level.

Recovery Process Mass Balance

Four cases have been identified for the quantity of feed solution delivered to the cadmium recovery process. They are:

- Case 1A - 30 shops participating; wastes are delivered as cadmium solutions and ion exchange modules
- Case 1B - 30 shops participating; all wastes are concentrated on ion exchange modules before shipment to recovery facility
- Case 2A - All Cleveland shops participating; wastes are delivered as cadmium solutions and ion exchange modules
- Case 2B - All Cleveland shops participating; all wastes are concentrated on ion exchange modules before shipment to the recovery facility

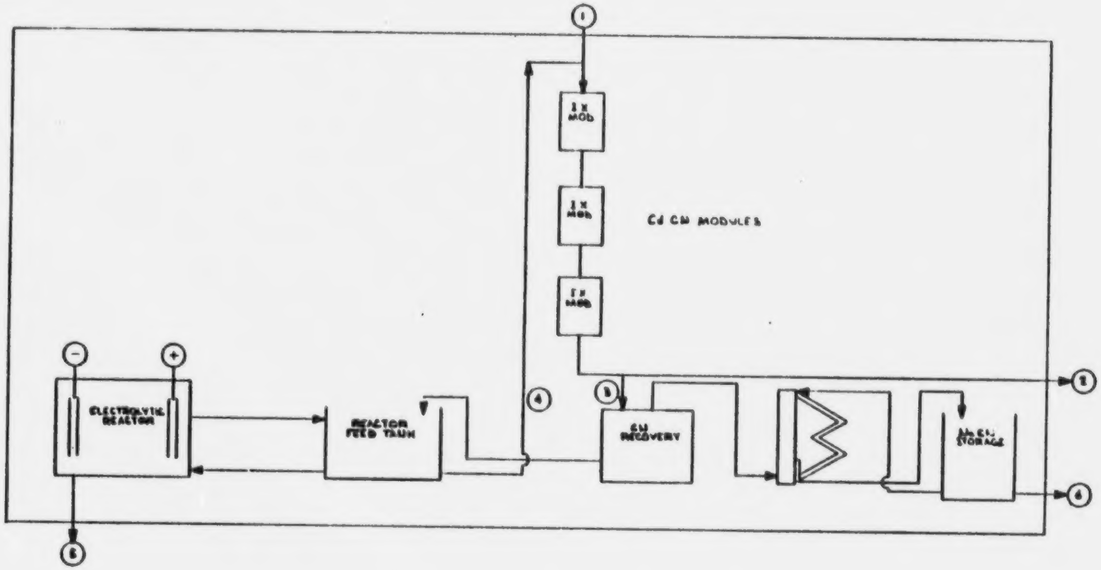
Using these four cases, Figure 22 presents the material balance for the recovery process in terms of feed rate, wastewater requiring treatment, quantity of products (NaCN and cadmium) and utility consumption. The balance only considers the wastes that are concentrated on ion exchange resins as recovery feed material. Concentrated cadmium solutions are treated in the waste treatment system.

Developmental Requirements

The major uncertainty associated with process is the efficiency of electrolytic recovery at concentrations of 30 to 40 g/L and the influence of low concentrations of more noble metals such as copper on the electrolytic reaction. Pilot data needs to be generated regarding reaction rates for sizing the electrolytic reactor.

Other areas which require investigation are the efficiency of the anion columns regeneration using an acid solution rich in cadmium and design parameters for the cyanide recovery system.

(To provide the reader with complete
information, this reduced schematic
drawing is included in the report.
This is the best copy available; we
regret that portions are undecipherable.)



①
IX MOD.
IX MOD.
IX MOD.
Cd CN MODULES
②
③
④
CN RECOVERY
NaCN STORAGE
⑥
−
+
ELECTROLYTIC REACTOR
REACTOR FEED TANK
⑤

	① CADMIUM CN IX MOD.		② Cd CN WASTE WATER		③ IX REGENERANT	④ ELECTROLYTIC SOLUTION	⑤ Cd METAL PRODUCT	⑥ NaCN PRODUCT CONCENTRATED		UTILITIES		
	[illegible]	lb Cd/d	gpm	mg Cd/l	mg Cd/l	mg Cd/l	lb Cd/d	gm NaCN/l	gpm	H_2O gpm	NaOH lb/d	KW
CASE 1A	0	–	–	–	–	–	–	–	–	–	–	
CASE 1B	11.6	28.1	475	1770	53000	30000	21	500	28	475	77	
CASE 2A	16.4	39.8	670	1770	53000	30000	30	500	39	670	109	
CASE 2B	18.8	68.9	1170	1770	53000	30000	52	500	69	1170	188	

Figure 22. Cadmium recovery system mass balance

Economic Analysis

The economic benefit of cadmium recovery is based on the revenues obtained from the sale of the recovered cadmium and sodium cyanide and on the avoidance of the costs associated with treatment of these pollutants and disposal of the solid waste. The following basis will be used to calculate the economic benefits of the cadmium recovery system:

Cadmium Cyanide - Based on 75 percent recovery of cadmium and cyanide contained in feed, all values based on amount of cadmium in feed.

(a) Treatment cost[7] - \$1.30/lb Cd (This is based on using Cl_2 and NaOH for CN oxidation; the cost is \$2.75/lb Cd if NaOCl is used)

(b) Disposal cost - \$.39/lb Cd (based on twice theoretical solids generation; disposal at 25 percent solids @ \$.50 per gallon)

(c) Revenue - \$1.92/lb Cd (based on 75 percent of market value for Cd and NaCN)

(d) Recovery process chemical cost - \$.22/lb Cd

(e) Net savings - \$3.39/lb Cd (if NaOCl is used for oxidation, net becomes \$4.84/lb Cd)

The savings are based on the amount of cadmium in the recovery system feed. The savings per pound of cadmium recovered is \$4.52/lb. It is significant that of the \$3.39 per pound saved, \$1.82 is related to avoidance of the cost for chemical oxidation of the cyanides and sale of the recovered sodium cyanide. This underscores the need to have a market for the NaCN to achieve the potential savings.

Using these savings as a basis, the annual savings realized by cadmium recovery are shown in Figure 23 as a function of the amount of cadmium in the recovery process feed stream. Using this cost formula, the annual savings for the four waste flow cases are:

- Case 1A - 0
- Case 1B - \$23,800
- Case 2A - \$33,700
- Case 2B - \$58,400

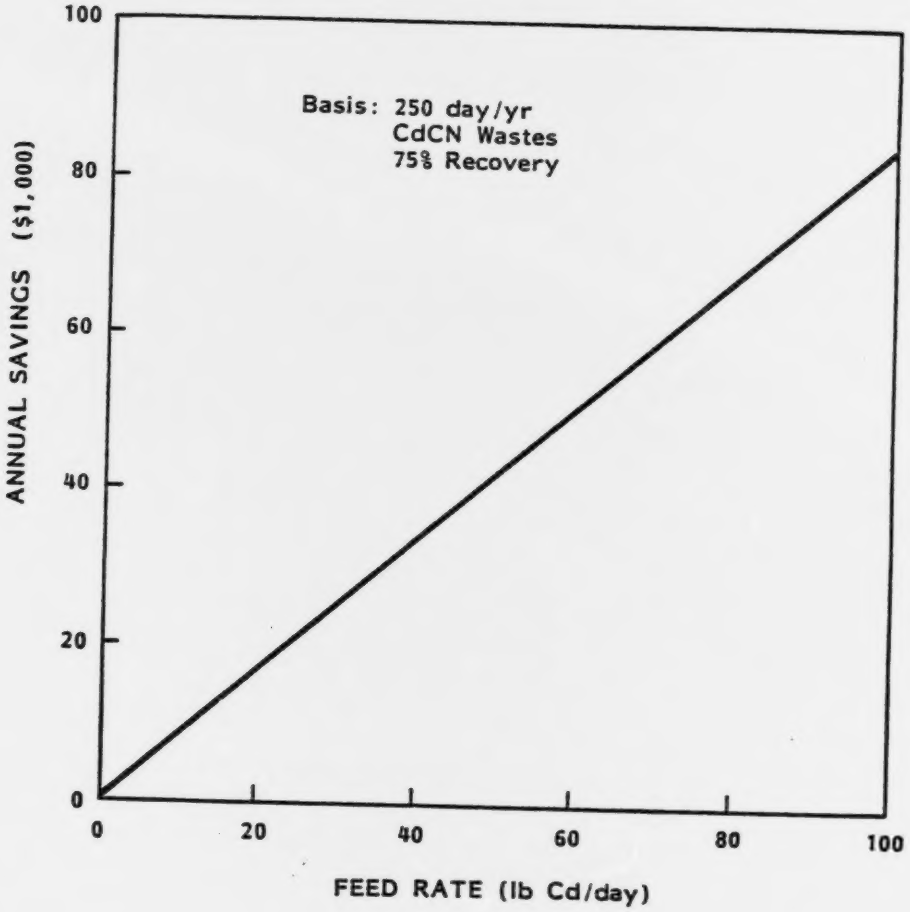


Figure 23. Annual Savings Derived from Cadmium Recovery

The savings represent the incentive to build and operate a cadmium recovery system. The breakdown of the cost of the equipment associated with the system is presented in Table 26. The cost in Table 26 is for a system with a recovery capacity of 100 lb of cadmium per day in the system feed. The cost for this system would be $120,000. The limiting factor in the recovery process capacity is the electrolytic reactor, which is assumed to operate continually 24 hours per day. The balance of the system would only need to operate one shift per day.

Using this operating basis, the annual cost of the recovery system is presented in Table 27.

As the Table indicates, reasonable return on investment is realized if the system operates at full capacity. The simple pre-tax ROI for the four waste flow cases are as follows:

- Case 1A - No return
- Case 1B - No return
- Case 2A - No return
- Case 2B - 20%

NICKEL RECOVERY PROCESS

The major sources of nickel wastes are the rinses following nickel plating baths. The nickel contained in the rinse water can be concentrated in ion exchange resins and transported to the central treatment facility. The regenerated nickel solution from the resin modules would provide the feed for the recovery process.

Recovery Process

The proposed recovery process is similar to one utilized at Chuo Electroplating Industrial Cooperative in Japan.[14] It recovers nickel from a concentrated nickel sulfate solution by plating it onto a cathode in a diaphragm cell. The use of a diaphragm cell overcomes many of the problems associated with electrolytic removal of nickel. The pH of the catholyte can be controlled and buffering agents are not as readily oxidized. Nickel can be removed from the catholyte to a concentration of 1,000 mg Ni/liter. The anolyte can be used to partially regenerate the ion exchange modules.

The major components of the recovery system are shown in Figure 24. To keep the investment cost at a minimum, the system is designed to recover wastes from ion exchange modules only.

TABLE 26. CADMIUM RECOVERY SYSTEM

Process Equipment (Installed Cost)	
A. Electrolytic Reactor 60 ft^2 cathode area)	$ 40,000
B. Tanks:	
Reactor Feed Tank @ 5,000 gal	7,000
CN Recovery @ 2,000 gal	4,000
NaCN Storage @ 2,000 gal	4,000
C. HCN Scrubber	5,000
D. Pumps (3 required, each with spare, low capacity)	9,000
Process Equipment Total	$ 69,000
E. Piping, Instrumentation and Reagent Supply (20% of process equipment)	14,000
F. Contingency (25% of process equipment)	17,000
G. Building Space	ND
Total Installed Cost	$100,000
Development and Design (20% of Installed Cost)	20,000
Total Cost	$120,000

ND = Not Determined

TABLE 27. ANNUAL COST OF CADMIUM RECOVERY SYSTEM

Investment Cost	$120,000
Annual Costs	($/yr)
Depreciation	12,000
Maintenance	7,200
Labor (4 hrs/shift @ $15/hr)	15,000
Total Annual Cost	$ 34,200
Revenues (100 lb/d)	$ 84,000
Net Revenues	$ 49,800
Simple Pre-tax ROI	42%

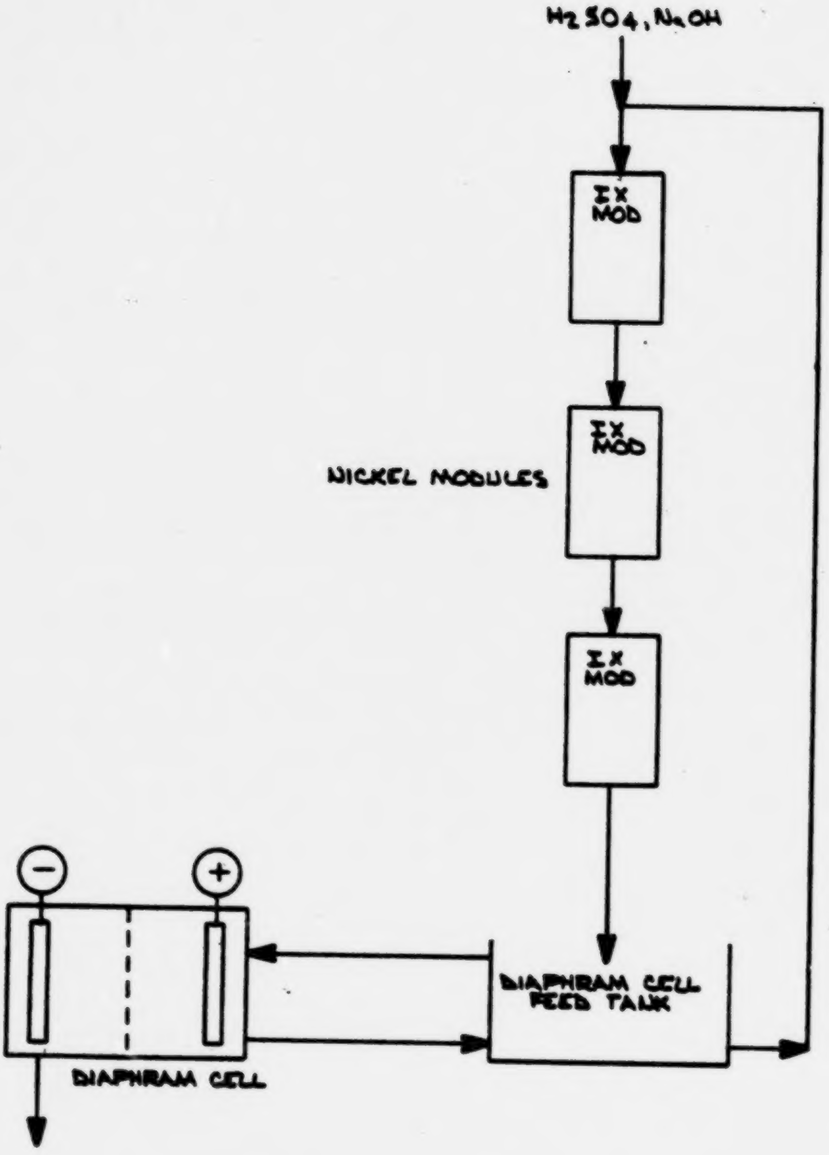

H2SO4, NaOH
IX MOD
IX MOD
NICKEL MODULES
IX MOD
DIAPHRAM CELL FEED TANK
DIAPHRAM CELL

Figure 24. Nickel recovery system

Recovery System Mass Balance

Four cases have been defined for the quanitity of nickel available for recovery. They are:

Case 1A - 30 shops participating; wastes are delivered as nickel solutions and ion exchange modules.

Case 1B - 30 shops participating; all wastes are concentrated on ion exchange modules before shipment to recovery facility.

Case 2A - All Cleveland shops participating; wastes are delivered as nickel solutions and ion exchange modules.

Case 2B - All shops participating; all wastes are concentrated on ion exchange modules before shipment to the recovery facility.

Using these four cases, Figure 25 presents the material balance for the recovery process in terms of feed rate, wastewater requiring treatment, quantity of nickel recovered and utility consumption. The balance considers only wastes concentratd in ion exchange modules; nickel concentrates are treated in the waste treatment system.

Developmental Requirements

Performance data and design parameters are needed for the electrolytic recovery of nickel in a diaphragm cell. The impact of solution impurities, such a more noble metals, must also be ascertained.

Economic Analysis

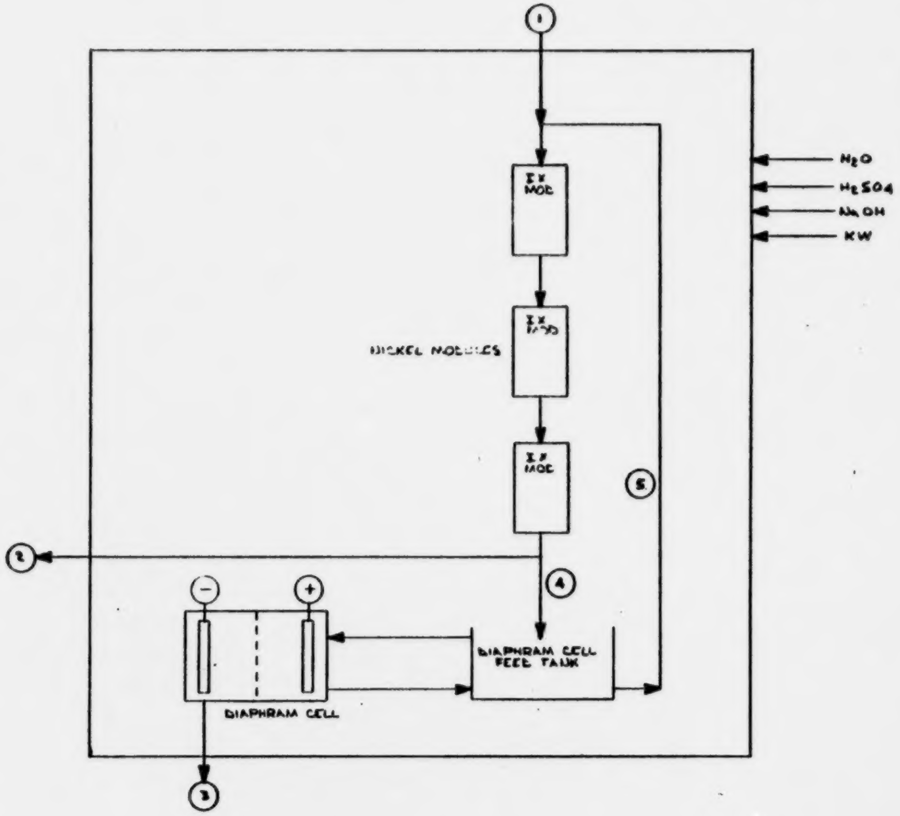
The economic benefit of the recovery process is derived from the revenues obtained from sale of the nickel metal and avoidance of the cost of treating the waste and disposing of the resultant sludge. Based on recovering 75 percent of the nickel, these savings amount to:

(a) Treatment Cost[7] - \$.15/lb Ni (NaOH neutralization)

(b) Disposal Cost - \$.47 lb Ni (based on twice theoretical solids generation, dsiposal at 25 percent solids concentration @ \$.50 per gallon)

(c) Revenue - \$1.18/lb Ni (based on 75 percent of market value of nickel metal)

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)


①
IX MOD
IX MOD
NICKEL MODULES
IX MOD
②
④
⑤
DIAPHRAM CELL FEED TANK
−
+
DIAPHRAM CELL
③
H_2O
H_2SO_4
NaOH
KW

	① IX MODULES		② WASTE WATER		③ NI METAL PRODUCT	④ REGENERANT CONCENTRATE	⑤ ELECTROLYTIC SOLUTION	UTILITIES			
	ft^3/d	lb Ni/d	gpd	mg Ni/l	lb/d	mg Ni/l	CONCENTRATE mg Ni/l	H_2O gpd	NaOH lb/d	H_2SO_4 lb/d	KW
CASE 1A	7.3	13.3	327	1200	10.0	21000	10000	327	23	28	
CASE 1B	12.0	22.0	540	1200	16.5	21000	10000	540	37	46	
CASE 2A	26.9	49.2	1210	1200	36.9	21000	10000	1210	84	103	
CASE 2B	32.6	59.6	1460	1200	44.7	21000	10000	1460	101	124	

Figure 25. Nickel recovery system mass balance

(d) Recovery Process Chemical Cost - $.25/lb Ni

(e) Net Savings - $1.55/lb Ni

The net savings is based on the amount of nickel in the recovery system feed. The savings per pound of nickel recovered is $2.07 per pound. Using these savings as a basis, the annual savings generated by nickel recovery are presented as a function of the amount fed to the recovery process in Figure 26.

The savings represent the incentive to build and operate a copper recovery system. The cost of the different equipment components shown in Figure 24 are presented in Table 28. The cost is for a system with a feed capacity of 100 pounds of nickel per day. The cost projected for the diaphragm cell is the major cost item and also the major source of uncertainty in the cost estimate as they are not currently marketed for this application. The cost of the system is estimated at $103,000.

The operating cost and return on investment for the system is shown in Table 29. Based on reclaiming 100 pounds of nickel per day, the return is only 7 percent. With the amount of nickel available for recovery in the four cases presented, the system would not generate enough revenue to offset operating costs.

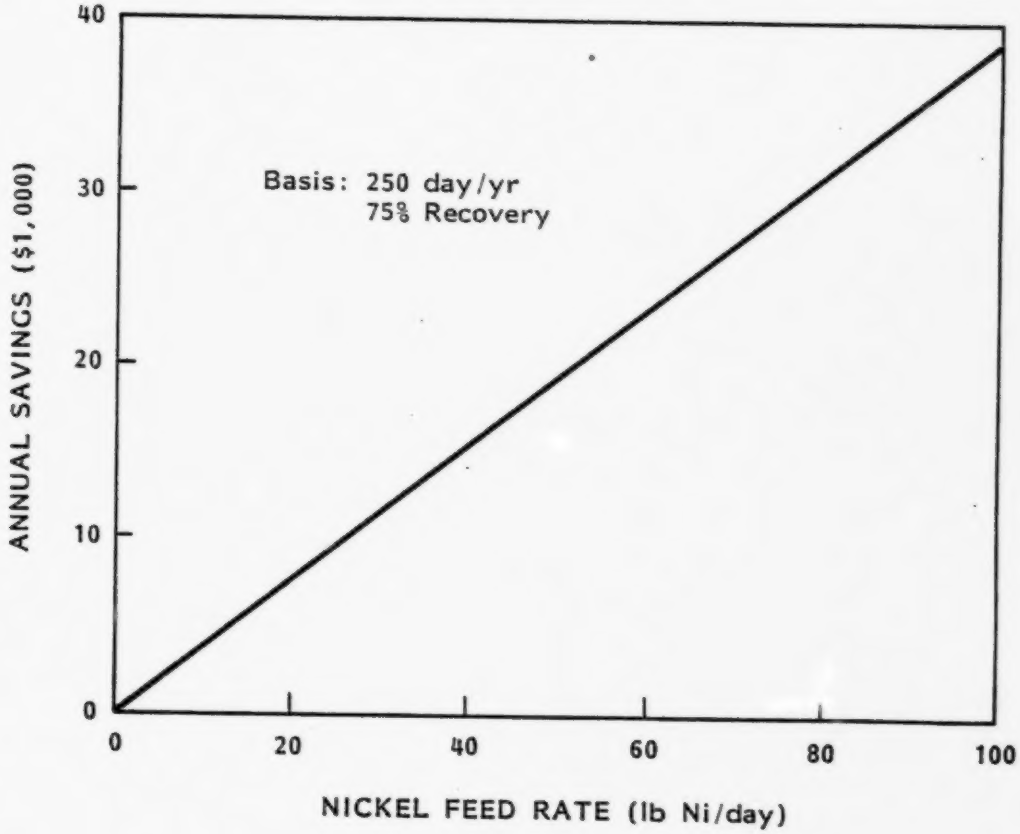


Figure 26. Annual Savings from Nickel Recovery

TABLE 28. NICKEL RECOVERY SYSTEM

Process Equipment (Installed Cost)		
A.	Diaphragm Cell	$ 50,000
B.	Tanks: Reactor Feed Tank @ 5,000 gal	7,000
C.	Pumps (1 required with spare, low capacity)	4,000
Process Equipment Total		$ 61,000
E.	Piping, Instrumentation and Reagent Supply (20% of process equipment)	10,000
F.	Contingency (25% of process equipment)	15,000
G.	Building Space	ND
Total Installed Cost		$86,000
Development and Design (20% of Installed Cost)		17,000
Total Cost		$103,000

ND = Not Determined

TABLE 29. ANNUAL COST OF NICKEL RECOVERY SYSTEM

Investment Cost	$103,000
Annual Costs	($/yr)
Depreciation	10,300
Maintenance	6,200
Labor (4 hrs/shift, 1 shift/day, @$15/hr)	15,000
Annual Cost Total	$ 31,500
Revenues (100 lb Ni/day)	38,500
Net Revenues	7,000
Simple Pre-tax ROI	7%

Note - Tax advantages for pollution control and energy saving equipment could improve the profitability of the recovery process.

SECTION 7

CONCEPTUAL DESIGN OF THE RESOURCE RECOVERY PARK

WASTE TREATMENT AT THE RESOURCE RECOVERY PARK

There are a variety of configurations that exist or could be used for a central treatment system. Figure 27 presents one of the configurations most applicable to highly industrialized areas. In the example system, the area represented is an industrialized metropolitan area typically found in the midwest and northeast. The industrialized sectors of the city are located outside the central business district. The central processing facility also is located outside the central business district and away from the residential areas. However, the facility must be located close enough to industry to allow economical waste hauling. Also, the central facility must be sited close to major transportation routes to allow truck transport. Waste hauling through the business district and residential areas should be minimized.

Although it would be convenient to locate the disposal site next to the central processing facility from a siting standpoint, this would be impossible in most metropolitan areas. The major obstacle in disposal siting is the public's refusal to allow industrial waste to be permanently discarded near residential and business sectors. Also, the disposal area may require a large tract of land which would be very expensive within the metropolitan area. Therefore, the disposal site, in most instances, must be located at least 10 miles outside the metropolitan area.

During operation, industrial wastes would be collected from participants on an as-needed basis or according to a set schedule. The waste would be transported by trucks using major highways and usually circumventing residential and business areas. The waste would be delivered to the central facility and processed. Any recovered materials would be shipped to appropriate markets, residual solids (usually sludge) would be sent to the disposal site. The treated liquid effluent from the central processing would be discharged to the city sewer system.

Figure 28 illustrates the layout of a typical central processing facility. The facility site would be secured by fencing to prevent unwanted entry. Within the site there would be an administrative office, analytical laboratory and a

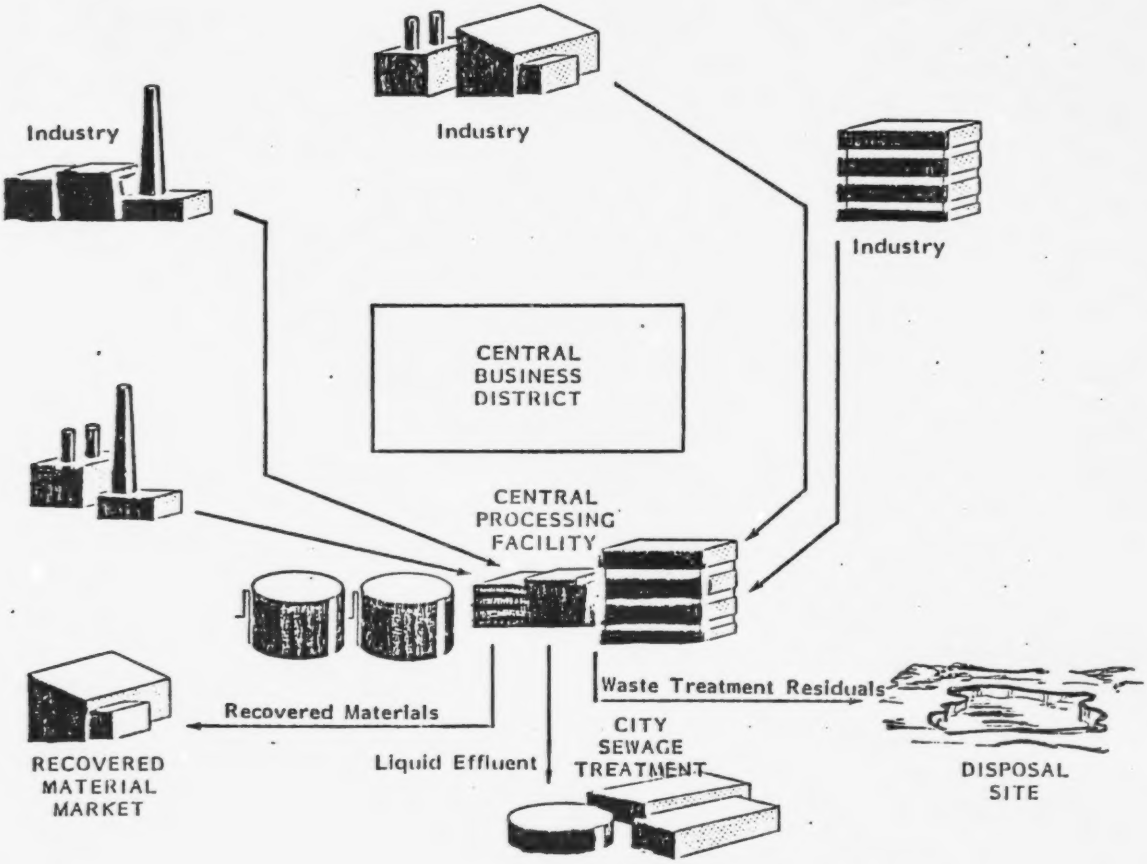

Industry
Industry
Industry
CENTRAL BUSINESS DISTRICT
CENTRAL PROCESSING FACILITY
Recovered Materials
RECOVERED MATERIAL MARKET
Liquid Effluent
CITY SEWAGE TREATMENT
Waste Treatment Residuals
DISPOSAL SITE

Figure 27. Central Treatment System Overview

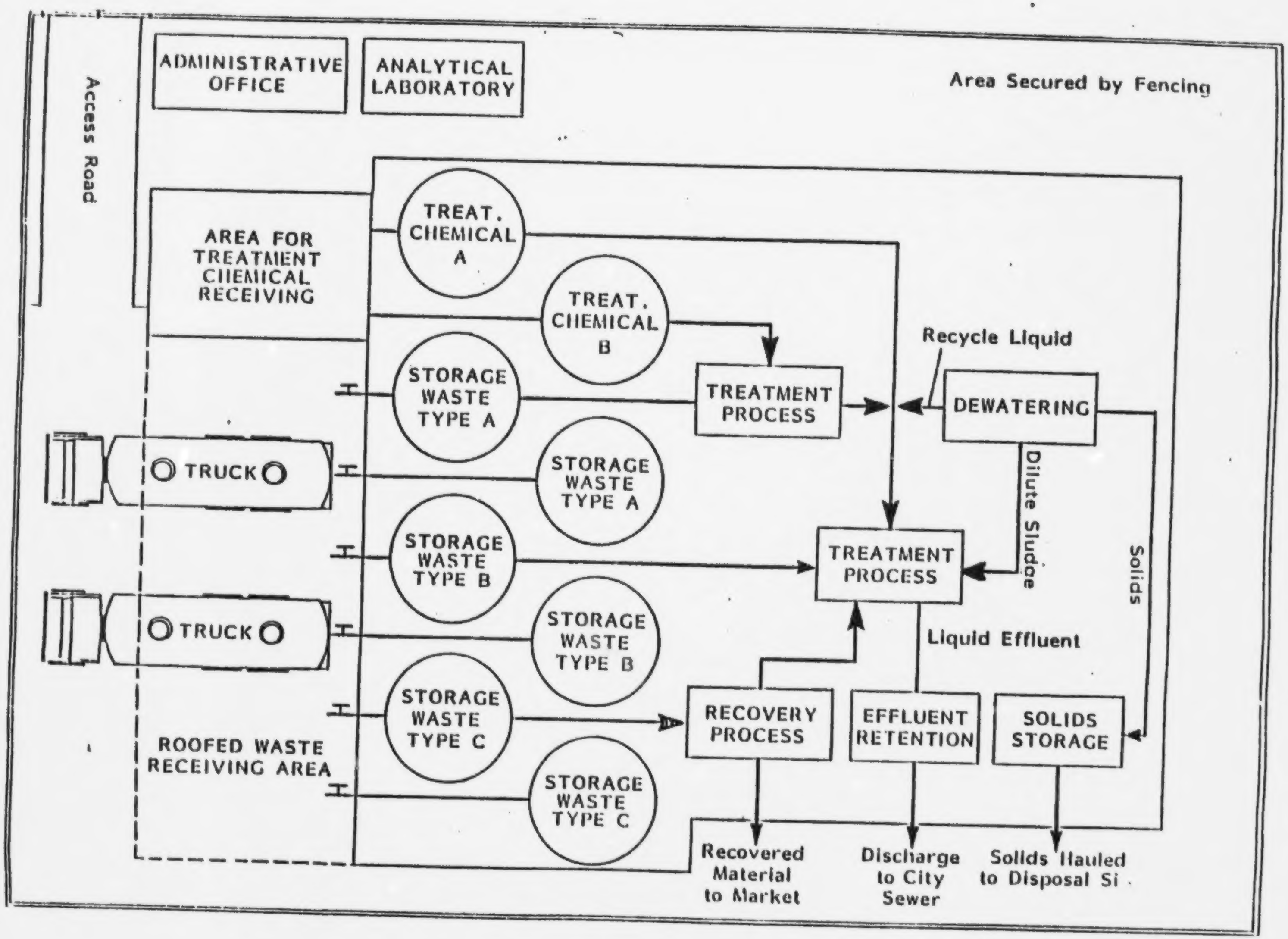

Access Road
ADMINISTRATIVE OFFICE
ANALYTICAL LABORATORY
Area Secured by Fencing
AREA FOR TREATMENT CHEMICAL RECEIVING
TREAT. CHEMICAL A
TREAT. CHEMICAL B
STORAGE WASTE TYPE A
STORAGE WASTE TYPE A
STORAGE WASTE TYPE B
STORAGE WASTE TYPE B
STORAGE WASTE TYPE C
STORAGE WASTE TYPE C
TRUCK
TRUCK
ROOFED WASTE RECEIVING AREA
TREATMENT PROCESS
Recycle Liquid
DEWATERING
Dilute Sludge
Solids
TREATMENT PROCESS
Liquid Effluent
RECOVERY PROCESS
EFFLUENT RETENTION
SOLIDS STORAGE
Recovered Material to Market
Discharge to City Sewer
Solids Hauled to Disposal Si

Figure 28. Central processing facility

building containing waste processing equipment. The waste receiving area would be located at the perimeter of the process building.

During operation, trucks hauling waste would enter the central facility site and be received by a plant operator. The waste hauler would identify his waste by customer and waste type. The operator would take a sample of the waste for analysis and assign the waste to a receiving dock. Waste analysis would be performed as necessary to determine if the nature of the accepted waste is as stated by the hauler.*

The waste is either dumped into receiving pits or directly pumped to the appropriate storage tank. There it will be mixed with similar waste and enter the appropriate treatment process. In the illustrated example (Figure 28) Waste A receives a preliminary process step then is combined with Waste B and the unrecovered portion of Waste C. This mixture is then treated and the liquid effluent flows to a retention tank. This tank provides protection against the discharge of improperly treated effluent. The dilute sludge from the treatment process goes to dewatering to reduce the volume of waste requiring transport to the disposal site. The liquid from dewatering is usually contaminated with pollutants and is returned to the treatment process. The dewatered solids are stored in a tank to await shipment to the disposal site.

Individual waste generators would participate in a RRP system by first concentrating their wastes as much as possible before transport to the central facility. For electroplaters this can be achieved by either utilizing innovative rinsing techniques (e.g., series rinsing, still rinsing) or through application of a technology such as ion exchange. In the latter case, ion exchange equipment could be leased and serviced by the central facility management. Instead of sending concentrated rinsewaters, the ion-exchange cylinders would be transported to the central facility where they would be regenerated for treatment or recovery. The cost of these modules has been estimated as shown:

ION EXCHANGE MODULES

Vessel

PVC 1.5' x 5' H w/quick disconnect	$ 230 ea.

---

*If the waste is hazardous as defined by EPA (40CFR261), then a complete analysis of the waste must be available or performed before treatment.

Resin

5 ft^3 anion resin @ \$175/ft^3	\$875
5 ft^3 cation resin @ \$75/ft^3	\$357

Completed Modules

Anion	\$1,105
Cation	\$ 605

76-PLANT CAPACITY

As has been pointed out in Section 5, when it is assumed that all plants within the population that are presently exceeding effluent limitations send their wastes to the RRP, about 76 participants may be identified. The following description describes the process design, investment and operating cost, and resultant fee structure appropriate to service these participants.

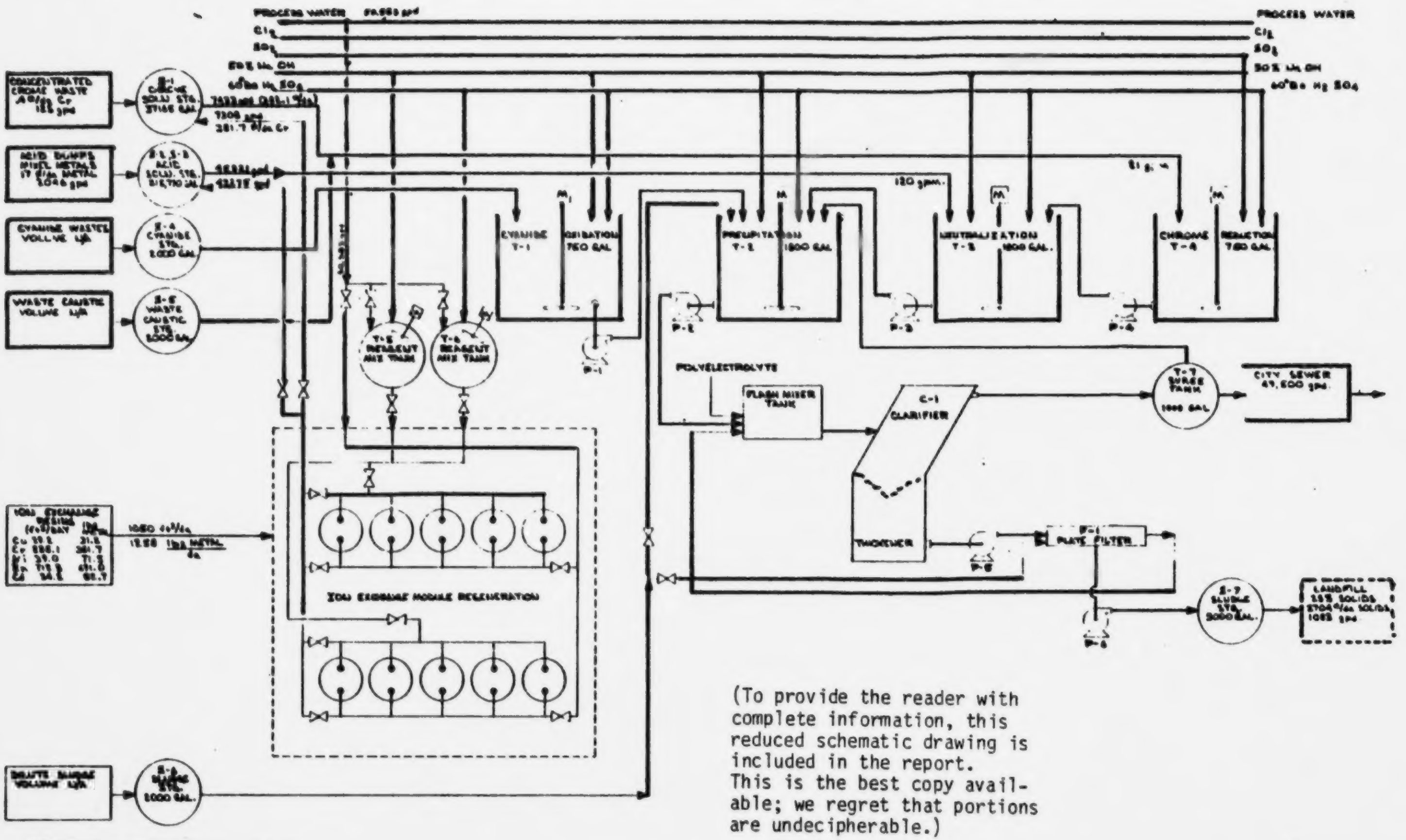
Process Design

The initial design of the Resource Recovery Park has been based on the latter concept described above whereby all dumps requiring treatment from all of the participating electroplaters are shipped to the Resource Recovery Park for disposal. In addition, all running rinses requiring treatment are serviced by in-plant ion exchange modules leased to the plater by the Resource Recovery Park. When these modules require regeneration, they are trucked back to the Resource Recovery Park, where regeneration followed by treatment of the regenerant and disposal of residuals takes place.

The process design of the 76-plant capacity RRP is presented in Figure 29. All expected flows and material balances are noted on the drawing.

Investment and Operating Cost

The capital investment required to construct the Resource Recovery Park, 76-plant capacity design, is presented in Table 30. The cost of the required 3-acre site is based on actual quotes for industrial land in Cleveland. The cost of buildings and structures are based on manufacturer's estimates of prefabricated building erection, complete with all utilities. The costs of the required process equipment are based on vendor's quotations. The second page of Table 30 presents item-by-item costs keyed to the process design, Figure 29.


PROCESS WATER
Cl_2
SO_2
50% NaOH
60°Be H_2SO_4
CONCENTRATED CHROME WASTE
ACID DUMPS MIXED METALS
CYANIDE WASTES VOLUME N/A
WASTE CAUSTIC VOLUME N/A
S-4 CYANIDE STG. 2000 GAL.
S-5 WASTE CAUSTIC STG. 2000 GAL.
T-5 REAGENT MIX TANK
T-6 REAGENT MIX TANK
CYANIDE T-1
OXIDATION 750 GAL.
P-1
PRECIPITATION T-2 1800 GAL.
P-2
120 gpm.
NEUTRALIZATION T-3 1800 GAL.
P-3
CHROME T-4
REDUCTION 750 GAL.
P-4
POLYELECTROLYTE
FLASH MIXER TANK
C-1 CLARIFIER
THICKENER
P-5
PLATE FILTER
P-6
T-7 SURGE TANK 1000 GAL.
CITY SEWER 47,500 gpd.
S-7 SLUDGE STG. 3000 GAL.
LANDFILL
ION EXCHANGE MODULE REGENERATION
DILUTE RINSE VOLUME N/A
S-6 RINSE STG. 2000 GAL.

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)

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best available copy.

Figure 29. Process design--76-plant capacity

TABLE 30. CLEVELAND RESOURCE RECOVERY PARK ALL PLANTS PARTICIPATING

Project Costs Summary

Land (3 acres @ 19,532)	$ 58,596	
Buildings and Structures	417,140	(see detail)
Process Equipment	614,978	(see detail)
Project Engineering	100,000	
Project Construction	200,000	
	1,390,714	
Contingency	140,000	
Startup Costs	30,000	
Total RRP Cost	$1,560,714	
Investment in Ion Exchange Modules	1,242,855	(see detail)
Total Capital Required	$2,803,569	

Table 30. Detail

(Refer to Figure 29)

DATE: 1-6-82 CASE 4

1.7-1

DESCRIPTION	UNIT PRICE	TOTAL PRICE
S-1 CHROMIC ACID STORAGE TANK LINED 21K GAL CAP 15'DIA 16' H	21800.00	21800.00
S-2,S-3 MIXED DUMP STG TANK LINED 125K GAL ERECTED (NO PAINT/FOUND)	42500.00	85000.00
S-4 CYANIDE STG TANK MILD STEEL 2000 GAL	8000.00	8000.00
S-5 WASTE CAUSTIC STG MILD STEEL 2000 GAL	8000.00	8000.00
S-6 DILUTE SLUDGE STG PAINTED MILD STL 1000 G	5000.00	5000.00
S-7 CONC. SLUDGE STG BIN	3000.00	3000.00
T-1,T-4 REACTION TANKS FRP-3-4" CON. 6'D X 4'H	2263.00	4526.00
T-2,T-3 REACTION TANKS FRP-3-4" CON.	1577.00	3154.00
T-5 REAGENT TANK	1000.00	1000.00
T-6 REAGENT TANK	1000.00	1000.00
T-7 SURGE TANK,CARBON ST *5000 GAL.	10000.00	10000.00
P-1,P-1A CN BATCH TRANSF	2000.00	4000.00
P-2,P-2A A/A, NEUT	3500.00	7000.00
P-3,P-3A PRECIP	3500.00	7000.00
P-4,P-4A	3500.00	7000.00
P-5,P-5A	3500.00	7000.00
P-6,P-6A SLUDGE PUMP	1500.00	3000.00
C-1 LAMELLA MOD 360/55 140 GPM - 200 PPM FEED	55000.00	55000.00
AG-1,AG-4 AGITATORS 3/4H	740.00	1480.00
AG-2,AG-3 AGITATORS 2 HP	1150.00	2300.00
INSTRUMENTS		
T-1 PH LOOP CONTROLS	5000.00	5000.00
T-4 ORP LOOP CONTROLS	5000.00	5000.00
T-2,T-3 PH LOOP CONTROL	2500.00	5000.00

Table 30. Detail (Cont.)

	Unit Price	Total Price
CHLORINATOR	1500.00	1500.00
SULFONATOR	1500.00	1500.00
C-1 CLARIFIER EFF PH IND ONLY	1500.00	1500.00
MCC MOTOR CONTROL CENTR	5000.00	5000.00
F-1 PRESS. PLATE FILTER	125000.00	125000.00
PN-1 CONTROL PANEL	3000.00	3000.00
SUBTOTAL		396760.00
CONTINGENCY 10%		39676.00
PIPING		59514.00
INSTALLATION		119028.00
TOTAL TREATMENT EQUIPMENT INSTALLED		614978.00
MISC ITEMS		
SPILL CONTROL	15000.00	15000.00
PAVING/PARKING (SQFT) 2000	15.00	30000.00
RAIL ROAD SPUR	0.00	0.00
FENCING 3A 6' C. LINK	12825.00	12825.00
LABORATORY	28675.00	28675.00
FORK LIFT LPG 5T LIFT	32000.00	32000.00
STORAGE BARRELS 418	30.00	12540.00
SUBTOTAL		131040.00
REAL ESTATE		
LAND AQUISITION	19532.00	58596.00
BUILDING SHELL	28.11	281100.00
UTILITY HOOKUP FEES	5000.00	5000.00
SUBTOTAL		344696.00
GRAND TOTAL COST->		1090714.00

NOTE:	
IX MODULES ANION	1105.00
NUMBER	1093
COST	1207765.00
IX MODULES CATION	605.00
NUMBER	58
COST	35090.00
TOTAL IX MODULES	1242855.00

Under the operating concept adopted here, the RRP will own the ion exchange canisters and will charge the participants a rental fee for their use. Therefore, the initial expense of purchasing the ion exchange systems is part of the required RRP investment.

The annual operating costs associated with the RRP are shown in Table 31. In each case a profit of 10 percent of annual operating costs is projected. Table 32 presents details of the chemical and utility costs for each treatment process.

Fee Structure

Table 31 results in a unit cost per gallon of wastewater shipped to (or, in the case of ion exchange, generated at) the RRP.* This unit cost, which does include an expected profit, represents one approach to the problem of setting a fee for the services of the RRP.

30-PLANT CAPACITY

Process Design

The process flows for which the RRP would be designed when the 30 visited shops are considered to participate are shown in Figure 30. Again, all running rinses within the participating shop are considered to be concentrated through the use of on-site ion exchange.

Investment and Operating Cost

Tables 33 through 35 present investment and operating costs for this configuration.

Fee Structure

Because economies of scale are not present to the extent they are when all plants participate, the fee shown in Table 34 is greater than the corresponding fee for the 76-plant design.

IN-PLANT CHANGES TO INCORPORATE ION EXCHANGE

Shops participating in the Resource Recovery Park will have to undergo the initial expense of purchasing equipment required to incorporate ion exchange treatment of the running rinses.

---

*The total annual production (12,644,500 gals/yr) is calculated as the sum of ion exchange regeneration solution (41,099 gpd) and batch dumps (2,171 gpd).

TABLE 31. CALCULATION OF WASTEWATER TREATMENT FEE

```
                             8 JANUARY 1982
                      ION EXCHANGE OPTION ALL PLANTS
                         76 PLANT CONFIGURATION

FACILITY NAME          CLEVELAND RESOURCE RECOVERY PARK
PREPARED FOR           INFORMATION
PREPARED BY            CENTEC
ANNUAL PRODUCTION        10.537,083
UNITS OF PRODUCTION    GALS OF WASTEWATER
CAPITAL COSTS ($)         1,560.714

  COST ITEMS         QUANTITY         RATE ($)       TIME      ITEM COST UNIT COST
--------------     -----------      ----------  ---------- ---------- ---------
SALARIES & WAGES:
PLANT MANAGER        1.00 MANYEAR  @ 32,000.00                  32,000     0.003
SECRATARY            1.00 MANYEAR  @ 12,000.00                  12,000     0.001
OPERATOR             1.00 MANYEAR  @ 20,000.00                  20,000     0.002
CHEMIST              1.00 MANYEAR  @ 25,000.00                  25,000     0.002
                                                            ----------   -------
  TOTAL SALARIES & WAGES                                        89,000     0.008
  ASSOCIATED OVERHEAD              @      58.00 %               51,620     0.005

UTILITIES:
ELECTRICITY        119.40 KWH      @       0.07    250 DAY       2,090     0.000
WATER            6,672.00 CU FT    @       0.01    250 DAY      24,520     0.002
                                                            ----------   -------
  TOTAL UTILITIES                                               26,609     0.003

CHEMICALS:
CAUSTIC          4,250.00 LB       @       0.14    250 DAY     148,750     0.014
SO2                765.70 LB       @       0.11    250 DAY      21,057     0.002
H2SO4              553.49 LB       @       0.04    250 DAY       5,535     0.001
POLY-E               5.06 LB       @       2.50    250 DAY       3,161     0.000
                                                            ----------   -------
  TOTAL CHEMICALS                                              178,503     0.017

PERCENT OF CAPITAL COST ITEMS:
MAINTENANCE                        @       6.00 %               93,643     0.009
INSURANCE                          @       2.00 %               31,214     0.003
CAPITAL RECOVER                    @      23.80 %              371,450     0.035
                                                            ----------   -------
  TOTAL PERCENT OF CAPITAL COST ITEMS                          496,307     0.047

OTHER COSTS:
HAUL/DISPOSAL    1,095.00 GAL      @       0.50    250 DAY     136,875     0.013
                                                            ----------   -------
  TOTAL OTHER COSTS                                            136,875     0.013

  SUBTOTAL                                                     978,914     0.093
  PROFIT                           @      10.00 %               97,891     0.009
                                                            ==========   =======
  TOTAL COST                                                 1,076,805     0.102
```

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TABLE 32. DETAILS OF CHEMICAL AND UTILITY COSTS
76-PLANT CAPACITY

```
CASE:  4          DATE: 1-7-82
------------------------------------------------------------------------------------------------------------
CONSUMPTION & COST FOR WASTE TRMT
----------------------------------------
BASIC INPUT DATA
-----------------
           +-----ION EXCHANGE-----++-----BATCH DUMPS -----++-----RINSES-----------++-----TOTAL ----------------------+
ACID/ALKALI-
NICKEL        4173  MG/L  2053   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD  4173  MG/L  2053   GPD 71.42   LBS
COPPER        2288  MG/L  1634   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD  2283  MG/L  1634   GPD 31.17   LBS
CADMIUM       5183  MG/L  1916   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD  5183  MG/L  1916   GPD 82.74   LBS
ZINC          2335  MG/L 35496   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD  2335  MG/L 35496   GPD 691.0   LBS
MIXED            0  MG/L     0   GPD 996.6  MG/L  2046   GPD     0  MG/L     0   GPD 996.6  MG/L  2046   GPD 17.00   LBS

CYANIDE-----
COPPER           0  MG/L     0   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD     0   LBS
ZINC             0  MG/L     0   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD     0   LBS
CADMIUM          0  MG/L     0   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD     0  MG/L     0   GPD     0   LBS

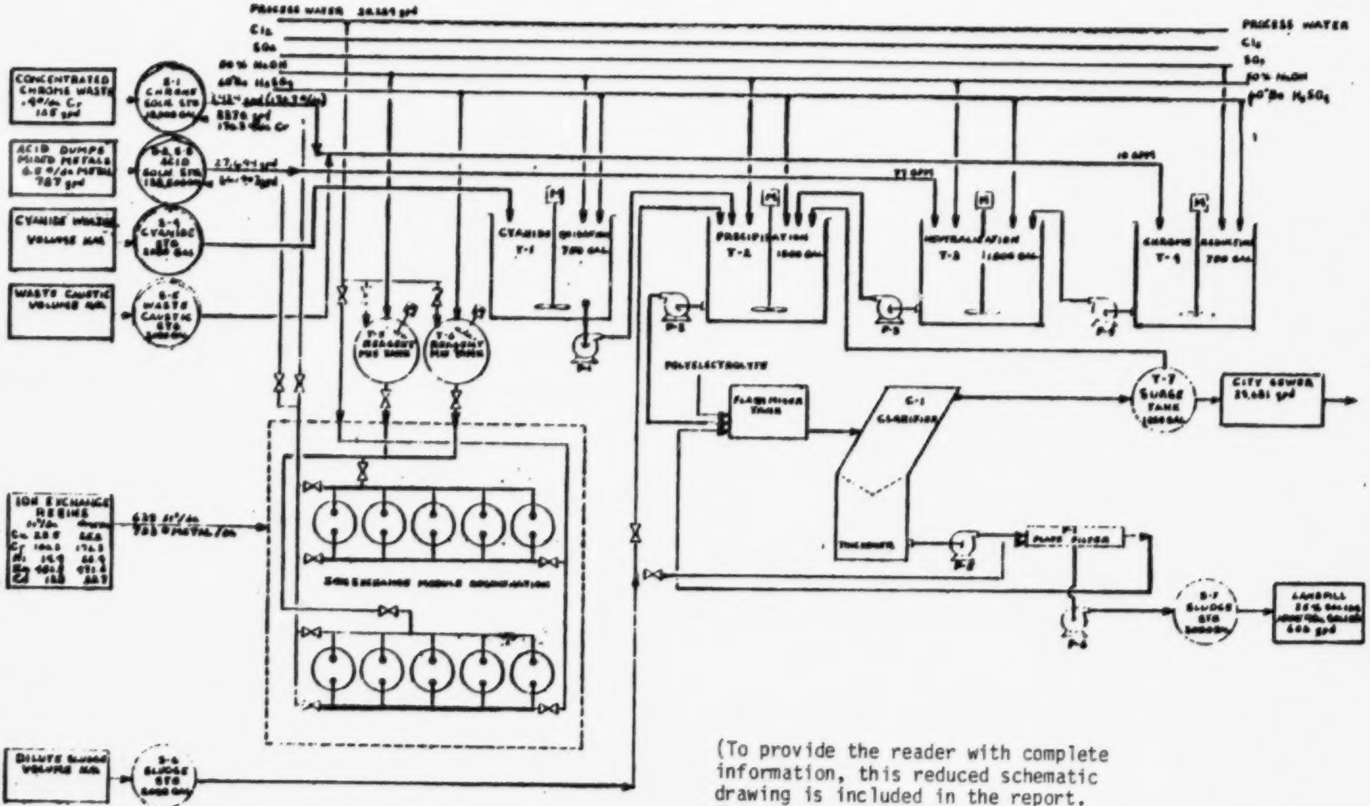
CHROME------  6265  MG/L  7308   GPD 383.8  MG/L   125   GPD     0  MG/L     0   GPD 6165.  MG/L  7433   GPD 382.1   LBS
------------------------------------------------------------------------------------------------------------
TOTALS
-----
A/A          14973  MG/L 43145   GPD 893.3   LBS
CYANIDE          0  MG/L     0   GPD     0   LBS
CHROME       6166.  MG/L  7433   GPD 382.1   LBS
------------------------------------------------------------------
CHEMICAL COSTS
-------------
NAME          COST      AMT      UNIT      $/UNIT
-------------------------------------------------
NAOH          0.14       1        LB        0.14
SO2           0.11       1        LB        0.11
H2SO4         0.04       1        LB        0.04
POLY-E        2.50       1        LB        2.50
CL2           0.07       1        LB        0.07
-------------------------------------------------
UTILITY COSTS
------------
NAME          COST     , AMT     UNIT      $/UNIT
-------------------------------------------------
WATER        14.73      1000     CUFT       .0147     GAL/DA 50583      AMT WTR.     6762.CU.FT. 99.61
ELEC          0.07         1      KWH        0.07     HP USE    20      AMT ELEC     119.4 KWH    8.36
-----------------------------------------------------------------------------------------------------
ION EXCHANGE       AMT   UNIT  WASTE            CHEMICAL    AMT/TRT      TREATMENT   AMOUNT       TREATMENT
TREATMENT              /DAY  STREAM                         UNIT         UNIT        USED         COST
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
               1050 FT3/DA                                                                                        IX
                                                 NAOH        1.5 FT3       1 FT3    717.9 LBS    26.56          TOTAL
                                                 H2SO4       1.5 FT3       1 FT3    552.0 LBS    20.42         $ /DAY
                                                 WATER         2 FT3       1 FT3    5107. FT3    75.21          122.2
                                                 ---------------------------------------------------------
```

(Continued)

TABLE 32. (Continued)

```
CONVENTIONAL       AMT   UNIT  WASTE                     CHEMICAL    AMT/TRT     TREATMENT   AMOUNT      TREATMENT
TREATMENT               /DAY  STREAM                                 UNIT        UNIT        USED          COST
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
REDUCTION          382.1 LB   CHROME
                    7433 LB                                SO2       2.00 LB        1 LB     765.7        80.40
                                                         H2SO4       0.20 LB     1000 GAL    1.497        .0550
----------------------------------------------------------------------------------------------------------------
OXIDATION              0 LB   CYANIDE
                       0 LB                                CL2       7.00 LB        1 LB         0            0
                                                          NAOH       8.00 LB        1 LB         0            0
----------------------------------------------------------------------------------------------------------------
NEUTRALIZATION   43145 GAL  HEAVY METAL                   NAOH       1.00 LB     1000 GAL    43.15        5.954
                  7433 GAL  CHROME                        NAOH       8.00 LB     1000 GAL    59.46        8.206
                                                                                                                      GAL/DA
----------------------------------------------------------------------------------------------------------------          25
PRECIPITATION    382.1 LB   CHROME                        NAOH       2.30 LB        1 LB     378.8        121.3    %DRY SOLIDS    %
                 1275. LB   OTHER METALS                  NAOH       2.00 LB        1 LB     2551.        352.0
                                                                                                                    2733.       1095.
----------------------------------------------------------------------------------------------------------------
FLOCCULATION     50578 GAL  ALL FLOWS                   POLY-E       0.10 LB     1000 GAL    5.058        12.64
----------------------------------------------------------------------------------------------------------------
CLARIFICATION        0 GAL  ALL FLOWS
----------------------------------------------------------------------------------------------------------------
SLUDGE STORAGE       0 GAL  ALL FLOWS
THICKENING
----------------------------------------------------------------------------------------------------------------
HAULING/DISPOSAL  1095. GAL  ALL FLOWS                               0.50 GAL       1 GAL    547.3        547.3
----------------------------------------------------------------------------------------------------------------
UTILITIES-----
ELECTRICITY  119.4KWH    @    0.07                                        TOTAL TREATMENT COST          1258.
WATER        6762.CU.FT. @     .0147

TOTAL CHEMICAL USAGE
----------------------
CAUSTIC       4250. LB   @         0.14    250   DAYS
SO2           765.7 LB   @         0.11    250   DAYS
H2SO4         553.5 LB   @         0.04    250   DAYS
POLY-E        5.058 LB   @         2.50    250   DAYS
CL2               0 LB   @         0.07    250   DAYS
```



PROCESS WATER 28,189 gpd
Cl_2
SO_2
20% NaOH
66°Be H_2SO_4
CONCENTRATED CHROME WASTE
S-1 CHROME SOLN STG
ACID DUMPS MIXED METALS
787 gpd
ACID SOLN STG
CYANIDE WASTE VOLUME N.A.
S-4 CYANIDE STG
WASTE CAUSTIC VOLUME N.A.
S-5 WASTE CAUSTIC STG
T-5 REAGENT MIX TANK
T-6 REAGENT MIX TANK
CYANIDE OXIDATION T-1 700 GAL
PRECIPITATION T-2 1500 GAL
NEUTRALIZATION T-3 1,000 GAL
CHROME REDUCTION T-4 700 GAL
P-1
P-2
P-3
P-4
P-5
P-6
10 GPM
POLYELECTROLYTE
FLASH MIXER TANK
C-1 CLARIFIER
THICKENER
T-7 SURGE TANK
CITY SEWER 29,681 gpd
F-1 PLATE FILTER
S-7 SLUDGE STG
LANDFILL 25% SOLIDS
606 gpd
ION EXCHANGE RESINS
ION EXCHANGE MODULE ORGANIZATION
DILUTE SLUDGE VOLUME N.A.
S-6 SLUDGE STG

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)

Reproduced from best available copy.

Figure 30. Process design--30-plant capacity

TABlE 33. CLEVELAND RESOURCE RECOVERY PARK 30-PLANT CAPACITY

Project Costs Summary

Land (3 acres @ 19,532)	$ 58,596	
Buildings and Structures	298,430	(see detail)
Process Equipment	568,865	(see detail)
Project Engineering	100,000	
Project Construction	200,000	
Total	1,225,891	
Contingency	120,000	
Startup Costs	28,000	
Total RRP Cost	$1,373,891	
Investment in Ion Exchange Modules	762,815	(see detail)
Total Capital Required	$2,136,706	

Table 33. Detail

DATE: 1-6-82 CASE 2

DESCRIPTION	UNIT PRICE	TOTAL PRICE
S-1 CHROMIC ACID STORAGE TANK LINED 18K GAL CAP 15'DIA 15' H	21800.00	21800.00
S-2,S-3 MIXED DUMP STG TANK LINED 75K GAL ERECTED (NO PAINT/FOUND)	27625.00	55250.00
S-4 CYANIDE STG TANK MILD STEEL 2000 GAL	8000.00	8000.00
S-5 WASTE CAUSTIC STG MILD STEEL 2000 GAL	8000.00	8000.00
S-6 DILUTE SLUDGE STG PAINTED MILD STL 1000 G	5000.00	5000.00
S-7 CONC. SLUDGE STG BIN	3000.00	3000.00
T-1,T-4 REACTION TANKS FRP-3-4" CON. 6'D X 4'H	2263.00	4526.00
T-2,T-3 REACTION TANKS FRP-3-4" CON.	1577.00	3154.00
T-5 REAGENT TANK	1000.00	1000.00
T-6 REAGENT TANK	1000.00	1000.00
T-7 SURGE TANK,CARBON ST "5000 GAL.	10000.00	10000.00
P-1,P-1A CN BATCH TRANSF	2000.00	4000.00
P-2,P-2A A/A, NEUT	3500.00	7000.00
P-3,P-3A PRECIP	3500.00	7000.00
P-4,P-4A	3500.00	7000.00
P-5,P-5A	3500.00	7000.00
P-6,P-6A SLUDGE PUMP	1500.00	3000.00
C-1 LAMELLA MOD 360/55 140 GPM - 200 PPM FEED	55000.00	55000.00
AG-1,AG-4 AGITATORS 3/4H	740.00	1480.00
AG-2,AG-3 AGITATORS 2 HP	1150.00	2300.00
INSTRUMENTS	-	
T-1 PH LOOP CONTROLS	5000.00	5000.00
T-4 ORP LOOP CONTROLS	5000.00	5000.00
T-2,T-3 PH LOOP CONTROL	5000.00	5000.00

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Table 33. Detail (Cont.)

	Unit Price	Total Price
CHLORINATOR	1500.00	1500.00
SULFONATOR	1500.00	1500.00
C-1 CLARIFIER EFF PH IND ONLY	1500.00	1500.00
MCC MOTOR CONTROL CENTR	5000.00	5000.00
F-1 PRESS. PLATE FILTER	125000.00	125000.00
PN-1 CONTROL PANEL	3000.00	3000.00
SUBTOTAL		367010.00
CONTINGENCY 10%		36701.00
PIPING		55051.50
INSTALLATION		110103.00
TOTAL TREATMENT EQUIPMENT INSTALLED		568865.50
MISC ITEMS		
SPILL CONTROL	15000.00	15000.00
PAVING/PARKING (SQFT) 2000	15.00	30000.00
RAIL ROAD SPUR	0.00	0.00
FENCING 3A 6' C. LINK	12825.00	12825.00
LABORATORY	28675.00	28675.00
FORK LIFT LPG 5T LIFT	32000.00	32000.00
STORAGE BARRELS 209	30.00	6270.00
SUBTOTAL		124770.00
REAL ESTATE		
LAND AQUISITION	19532.00	58596.00
BUILDING SHELL	28.11	168660.00
UTILITY HOOKUP FEES	5000.00	5000.00
SUBTOTAL		232256.00
GRAND TOTAL COST->		925891.50

NOTE:	
IX MODULES ANION	1105.00
NUMBER	675
COST	745875.00
IX MODULES CATION	605.00
NUMBER	28
COST	16940.00
TOTAL IX MODULES	762815.00

TABLE 34. CALCULATION OF WASTEWATER TREATMENT FEE

8 JANUARY 1982
ION EXCHANGE OPTION ALL PLANTS
30 PLANT CONFIGURATION

FACILITY NAME	CLEVELAND RESOURCE RECOVERY PARK
PREPARED FOR	INFORMATION
PREPARED BY	CENTEC
ANNUAL PRODUCTION	6,482,916
UNITS OF PRODUCTION	GALS OF WASTEWATER
CAPITAL COSTS ($)	1,373,891

COST ITEMS	QUANTITY	RATE ($)	TIME	ITEM COST	UNIT COST
SALARIES & WAGES:					
PLANT MANAGER	1.00 MANYEAR	@ 32,000.00		32,000	0.005
SECRATARY	1.00 MANYEAR	@ 12,000.00		12,000	0.002
OPERATOR	1.00 MANYEAR	@ 20,000.00		20,000	0.003
CHEMIST	1.00 MANYEAR	@ 25,000.00		25,000	0.004
TOTAL SALARIES & WAGES				89,000	0.014
ASSOCIATED OVERHEAD		@ 58.00 %		51.620	0.008
UTILITIES:					
ELECTRICITY	119.40 KWH	@ 0.07	250 DAY	2.090	0.000
WATER	4,049.00 CU FT	@ 0.01	250 DAY	14,880	0.002
TOTAL UTILITIES				16.970	0.003
CHEMICALS:					
CAUSTIC	2,371.00 LB	@ 0.14	250 DAY	82,985	0.013
SO2	353.70 LB	@ 0.11	250 DAY	9,727	0.002
H2SO4	336.60 LB	@ 0.04	250 DAY	3.366	0.001
POLY-E	3.11 LB	@ 2.50	250 DAY	1,944	0.000
TOTAL CHEMICALS				98.022	0.015
PERCENT OF CAPITAL COST ITEMS:					
MAINTENANCE		@ 6.00 %		82.433	0.013
INSURANCE		@ 2.00 %		27,478	0.004
CAPITAL RECOVER		@ 23.85 %		327,673	0.051
TOTAL PERCENT OF CAPITAL COST ITEMS				437,584	0.067
OTHER COSTS:					
HAUL/DISPOSAL	602.90 GAL	@ 0.50	250 DAY	75,363	0.012
TOTAL OTHER COSTS				75,363	0.012
SUBTOTAL				768,558	0.119
PROFIT		@ 10.00 %		76.856	0.012
TOTAL COST				845.414	0.130

TABLE 35. DETAILS OF CHEMICAL AND UTILITY COSTS
30-PLANT CAPACITY

```
CASE:  2          DATE: 1-7-82
----------------------------------------------------------------------------------------------------------------------
CONSUMPTION & COST FOR WASTE TREAT
----------------------------------------
BASIC INPUT DATA
-----------------
             +-----ION EXCHANGE-----++-----BATCH DUMPS -----++-----RINSES------------++-----TOTAL ---------------------+
ACID/ALKALI-
NICKEL        4173  MG/L 758.4   GPD      0  MG/L     0   GPD      0  MG/L     0   GPD  4173  MG/L 758.4  GPD 26.38   LBS
COPPER        2288  MG/L  1312   GPD      0  MG/L     0   GPD      0  MG/L     0   GPD  2288  MG/L  1312  GPD 25.03   LBS
CADMIUM       5180  MG/L   781   GPD      0  MG/L     0   GPD      0  MG/L     0   GPD  5180  MG/L   781  GPD 33.73   LBS
ZINC          2335  MG/L 24056   GPD      0  MG/L     0   GPD      0  MG/L     0   GPD  2335  MG/L 24056  GPD 468.3   LBS
MIXED            0  MG/L     0   GPD 996.6  MG/L   787   GPD      0  MG/L     0   GPD 996.6  MG/L   787  GPD 6.539   LBS
CYANIDE-----
COPPER           0  MG/L     0   GPD      0  MG/L     0   GPD      0  MG/L     0   GPD     0  MG/L     0  GPD     0   LBS
ZINC             0  MG/L     0   GPD      0  MG/L     0   GPD      0  MG/L     0   GPD     0  MG/L     0  GPD     0   LBS
CADMIUM          0  MG/L     0   GPD      0  MG/L     0   GPD      0  MG/L     0   GPD     0  MG/L     0  GPD     0   LBS

CHROME------  6265  MG/L  3376   GPD 383.8  MG/L    48   GPD      0  MG/L     0   GPD 6183.  MG/L  3424  GPD 176.5   LBS
----------------------------------------------------------------------------------------------------------------------
TOTALS
-----
A/A          14973  MG/L 27694   GPD 560.0   LBS
CYANIDE          0  MG/L     0   GPD     0   LBS
CHROME       6183.  MG/L  3424   GPD 176.5   LBS
----------------------------------------------------------------
CHEMICAL COSTS
-------------
NAME         COST      AMT     UNIT      $/UNIT
------------------------------------------------
NAOH         0.14       1       LB        0.14
SO2          0.11       1       LB        0.11
H2SO4        0.04       1       LB        0.04
POLY-E       2.50       1       LB        2.50
CL2          0.07       1       LB        0.07
------------------------------------------------
UTILITY COSTS
-------------
NAME         COST      AMT     UNIT      $/UNIT
                                                                                          $/DAY
------------------------------------------------
WATER       14.73     1000     CUFT      .0147     GAL/DA 30284     AMT WTR.     4049.     59.64
ELEC         0.07       1       KWH       0.07     HP USE    20     AMT ELEC     119.4      8.36
---------------------------------------------------------------------------------------------------
ION EXCHANGE        AMT   UNIT  WASTE              CHEMICAL    AMT/TRT    TREATMENT  AMOUNT     TREATMENT
TREATMENT               /DAY  STREAM                             UNIT       UNIT      USED        COST
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

(Continued)

TABLE 35. (Continued)

```
                                                    NAOH      1.5 FT3      1 FT3   436.9 LBS   16.16        IX
                                                    H2SO4     1.5 FT3      1 FT3   135.9 LBS   12.43      TOTAL
                                                    WATER       2 FT3      1 FT3   3103. FT3   45.78     $ /DAY
----------------------------------------------------------------------------------------------------      74.39
----------------------------------------------------------------------------------------------------
CONVENTIONAL      AMT   UNIT  WASTE              CHEMICAL    AMT/TRT     TREATMENT   AMOUNT      TREATMENT
TREATMENT               /DAY  STREAM                          UNIT        UNIT        USED         COST
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
REDUCTION        176.5 LB   CHROME                 SO2      2.00 LB        1 LB    351.7        37.13
                  3424 LB                         H2SO4     0.20 LB     1000 GAL   .6848        .0253
----------------------------------------------------------------------------------------------------
OXIDATION            0 LB   CYANIDE                CL2      7.00 LB        1 LB        0            0
                     0 LB                          NAOH     8.00 LB        1 LB        0            0
----------------------------------------------------------------------------------------------------
NEUTRALIZATION   27694 GAL  HEAVY METAL            NAOH     1.00 LB     1000 GAL   27.69        3.822
                  3424 GAL  CHROME                 NAOH     8.00 LB     1000 GAL   27.39        3.780      GAL/DA
----------------------------------------------------------------------------------------------------           25
PRECIPITATION    176.5 LB   CHROME                 NAOH     2.30 LB        1 LB    405.9        56.02   %DRY SOLIDS    %
                 736.5 LB   OTHER METALS           NAOH     2.00 LB        1 LB    1473.        203.3
                                                                                                        1505.      602.9
----------------------------------------------------------------------------------------------------
FLOCCULATION     31118 GAL  ALL FLOWS            POLY-E     0.10 LB     1000 GAL   3.112        7.780
----------------------------------------------------------------------------------------------------
CLARIFICATION        0 GAL  ALL FLOWS
----------------------------------------------------------------------------------------------------
SLUDGE STORAGE       0 GAL  ALL FLOWS
THICKENING
----------------------------------------------------------------------------------------------------
HAULING/DISPOSAL 602.9 GAL  ALL FLOWS                       0.50 GAL       1 GAL   301.4        301.4
----------------------------------------------------------------------------------------------------
UTILITIES-----
ELECTRICITY  119.4 KWH @     0.07
WATER        4049. CU.FT@    0.0147
                                                                   TOTAL TREATMENT COST      755.6
TOTAL CHEMICAL USAGE

CAUSTIC      2371. LB  @      0.14      250  DAYS
SO2          353.7 LB  @      0.11      250  DAYS
H2SO4        336.6 LB  @      0.04      250  DAYS
POLY-E        3.11 LB  @      2.50      250  DAYS
CL2              0 LB  @      0.07      250  DAYS
```

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While the modules will be provided to the shops by the RRP for a rental fee, ancillary equipment to service each rinse system must be purchased.

The cost of the ancillary equipment required to incorporate ion exchange modules in treatment system is estimated to be $800 per rinse system. It includes:

Outboard rinse arrangement - no cost

Pump - nominal rating 5 gpm at 30 psi	$500
2-inch hose with quick connect	100
Pump actuator	100
Electrical hook-up	100
TOTAL	$800

Table 36 presents the number of anion and cation modules required each week by each plant based on its volume of running rinses. The total investment for the ancillary equipment listed above is also shown for each plant.

TRANSPORTATION AND ION EXCHANGE RENTAL COST

Wastes will be transported to the RRP in trucks owned or leased by the RRP. The use of independent haulers is also possible. Solutions which are batch dumped will be stored in drums at the shops and the drums will be transported on flat bed trucks. Ion exchange modules will also be transported in this manner.

There are various sizes of flat bed trucks available which are capable of transporting drums and modules. Common sizes include bed lengths of 16, 20 and 24 feet with a standard width of 8 feet. For purposes of calculating transportation costs in the RRP system, a bed length of 20 feet was used. These trucks are capable of transporting 20 barrels or 30 modules per trip.

Trucking costs vary between localities because of variations in wages. In the Cleveland area the average cost for a 20-ft flat bed truck is $27/hr. Using this figure, the cost of transporting batch dump solution is approximately $0.10 per gallon or $5.50 per barrel. The cost of transportation per module is $3.60. This assumes that a truck will average two trips per 8-hour day.

The ion exchange modules will be owned by the RRP. The costs of these units will be recovered through rental fees paid

TABLE 36. NUMBER OF ANION AND CATION MODULES USED PER WEEK

Plant #	Anion	Cation	In-Plant Costs
1	12	1	2,400
2	1	0	800
3	7	6	0
4	213	0	3,200
5	1	1	1,600
6	6	1	2,400
7	2	0	800
8	39	0	800
9	15	0	2,400
10	0	0	0
11	1	1	0
12	0	0	0
13	1	0	2,400
14	23	0	2,400
15	2	0	1,600
16	1	0	800
17	5	0	800
18	0	0	0
19	2	1	1,600
20	7	3	3,200
21	0	0	0
22	1	0	800
23	0	0	0
24	0	0	0
25	1	7	1,600
26	4	0	2,600
27	10	0	2,400
28	2	0	1,600
29	ND	ND	ND
30	2	0	0
31	185	0	4,000
32	3	0	800
33	1	1	1,600
34	2	0	800
35	0	0	0
36	0	1	800
37	0	1	800
38	1	0	800
39	1	0	800
40	3	0	800
41	0	0	0
42	1	0	800
43	0	0	0
44	3	2	1,600

TABLE 36. (Continued)

Plant #	Anion	Cation	In-Plant Costs
45	2	0	1,600
46	0	0	0
47	0	0	0
48	1	0	800
49	59	0	160
50	81	0	1,600
51	0	0	0
52	0	0	0
53	0	0	0
54	0	0	0
55	21	4	2,400
56	0	0	0
57	0	0	0
58	3	0	2,400
59	4	0	800
60	2	0	800
61	1	0	800
62	1	1	1,800
63	1	0	800
64	1	0	800
65	0	0	0
66	1	0	800
67	1	0	800
68	4	0	800
69	0	6	800
70	0	0	0
71	1	0	800
72	10	0	800
73	133	0	2,400
74	10	0	800
75	0	0	800
76	3	0	800
Totals	884	30	65,600

by the shops. As indicated in Table 30, the cost per module is $1,105 for an anion unit and $605 for a cation unit. The cost variation is a result in the cost difference between anion and cation resin which comprise the majority of the cost for the modules. These resins have approximately a 10-year life.

The number of ion exhange modules required for the RRP system depends on the number of spent modules generated by the shops and the pickup and delivery schedule of spent and regenerated modules. For purposes of the study a pickup rate of twice per week for each shop was used. Further, it is necessary to have for each shop 2.5 times as many modules as are transported each semi-weekly collection day. This multiplication factor accounts for the spent modules taken to the RRP, the regenerated modules in the shop, and an additional number for a safety factor.

The rental costs for the modules have been calculated based on recovery of capital investment over the expected 10 year life at an assumed cost of funds of 20 percent (CRF = .2385). In addition, the expenses of maintenance and insurance (8 percent of the investment), and replacement of resin (one-tenth of the resin cost each year) are included in the rent. The annual rental fee is then $439 for an anion unit and $228 for a cation unit. For any particular plant these costs can be multiplied by the number of modules required each week and by a safety factor of 1.25 (Table 36) to determine annual fees.

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PART II. FINANCING

CLEVELAND RESOURCE RECOVERY PARK

SECTION 1

INTRODUCTION

CLEVELAND REINDUSTRIALIZATION

Any close examination of the structure of American industry will reveal that the manufacturing capability of the United States is based upon two foundations:

- The major manufacturing and distributing corporations
- The smaller manufacturers which provide the specialized components and services needed by the larger manufacturers

The flexibility, drive and hands-on involvement of the owner/managers of these small firms have always provided a complementary balance to the large corporations--which have the capital, marketing, and distribution resources that allow them to participate in world markets.

Nowhere is the interdependence of small and large manufacturers in greater evidence than when the smaller manufacturers are competing for contracts to provide parts for the product of a major corporation. The aggregate employment of these smaller manufacturers usually equals and often exceeds that of the major corporations. There are few, if any, cities in the United States where this symbiotic relationship is better illustrated than in Cleveland, Ohio. Cleveland currently has manufacturing facilities owned by the top 500 U.S. corporations, and facilities owned by independent operators.

The independent facilities consist of:

- Job Shop Electroplaters
- Mechanical Fabricators
- Specialty Formulators
- Printed Circuit Board Manufacturers

- Surface Finishers

- Specialized Repair and Maintenance

The combination of resources, transportation, labor and proximity to markets which brought the major industries to Cleveland in the past also brought a flourishing array of small manufacturers to provide the services and products needed by the larger corporations. All of the current problems of the larger corporations such as aging equipment and lack of capital for modernization have been even more intensely felt by the smaller manufacturers. It has reached the point where most do not have the capital, or credit, to introduce known technology for improving their efficiency. This has finally reached a crisis for many companies, who are unable to afford the equipment necessary to control toxic wastes generated by their facilities.

Most of Cleveland's manufacturers are faced with the same list of requirements:

- Modernizing aging production lines with equipment which will improve productivity and lower manufacturing costs

- Reducing energy costs

- Controlling pollution to acceptable levels

- Improving working conditions

Credit availability, high interest rates, and current depressed economic conditions help prevent the small manufacturers from raising the capital to meet these goals.

The favorable conditions which initially placed the city of Cleveland in a leading position in the American industrial community are still present. This is true of most northern cities whose industrial facilities are having economic problems. Given a revitalizing influx of capital improvements, these cities can regain their world leadership.

Over the long run, the rebuilding of Cleveland's industrial facilities is an essential and wise investment. The underlying question, however, relates to finding the most practical and cost-effective method of proceeding. Under current conditions there is insufficient capital available for a plant-by-plant modernization. Obtaining early results is a special challenge.

The answer appears to lie in a concept initially developed to reduce the costs of complying with pollution control requirements for small manufacturers. Numerous studies[1] have shown that, for most industrial cities, major savings in total pollution control costs could be obtained if a centralized facility is established to treat the concentrated wastes of a number of manufacturers. This concept has been in practice in the Ruhr Valley of Germany for over ten years, with almost complete success. The facilities have been funded both privately and by municipalities (using their credit and capital). In all cases they are fully supported by fees charged to those sending wastes to the facility, yet fees represent major savings to the participating industries over building individual facilities.

The centralized concept for waste treatment offers relief for only one of the problems facing most manufacturers. The problems of replacing outdated equipment, obtaining cheaper energy, and incorporating cost saving automation remain. The resolution of these additional problems for small manufacturers is incorporated into the concept of the Cleveland Resource Recovery Park.

The Cleveland Resource Recovery Park would not only provide waste treatment for all occupants, and those within a practical shipping range, but would offer the following seven additional features:

- Facilities for recovering components of wastes where economically feasible
- Sites for relocating and modernizing facilities where the current location is limited
- Low cost steam and electricity through a central boiler-cogeneration facility
- Centralized laboratory facilities
- Guided establishment of distributed computing services
- A pool of credit for qualifying participants
- Centralized shipping services

The project would be developed as a private corporation, with stock sold to participating manufacturers and private investors. The corporation would realize profits through the improved value of the land for industrial sites, sale of the materials recovered, utility and service charges, user fees for waste treatment, charges for services, and investment tax credits. The participants would pay for these services and realize additional profits because of the increased efficiency of their operations and reduced manufacturing costs.

Because of the innovative nature of the approach, and its high potential for resolving a major national problem, it is expected that the initial "prove out" of the concept in Cleveland will be eligible for both federal and state assistance through loan guarantees and direct grants. This assistance will not be necessary in other cities once the original Cleveland "proof of the concept" is complete.

This report provides a brief description of the organization, business plan and economics of the project. The initial focus of the concept as described herein has been on the electroplating industry, an industry badly in need of the cost savings and opportunities for renewal of facilities which the Cleveland Resource Recovery Park provides. While the projections contained in this report envision the participation of the electroplating industry alone, they are indicative of the potential benefits of reindustrialization when applied to the full scope of industrial activity to which the concept is applicable.

THE RESOURCE RECOVERY PARK

The electroplating industry is the first of 34 industries in the country to have to comply with pretreatment regulations and, as such, has an opportunity to set a pattern.

Cleveland, along with many other cities, has a concentration of metal plating shops whose wastes can contribute to high levels of heavy metal residues in sewage plant sludges.The Cleveland metropolitan area has more than 100 plating shops, employing more than 2,500 persons. Their services are used by a number of other industries, which need the plated products for their own products--automobiles, for instance.

An unusually large number of electroplating businesses are small--mom-and-pop type shops that cannot afford to buy the equipment needed to comply with federal regulations. It is estimated that more than 20 percent of the shops could be forced out of business.

At stake in Cleveland are approximately 2,500 jobs, employing a substantial number of city of Cleveland residents, particularly minority individuals. Cleveland's electroplaters, who apply metal finishes to fabricated metal products, provide a crucial service to other local firms and draw business from a region that reaches into Michigan and Pennsylvania. Any reduction in the size and capability of the plating industry could have a severe ripple effect on the Cleveland economy.

In 1979 and 1980, Cleveland was one of five metropolitan areas studied under federal contract for the feasibility of building central treatment facilities for the electroplating industry. Cleveland has been the subject of further study that has closely examined the economics of building a central treatment facility around which a number of plating companies could relocate near and many more could utilize the facility from their present locations.

One concept under consideration in the just completed Cleveland engineering study[2] was the creation of a combined, centralized pre-treatment facility/electroplaters' industrial park. Individual platers would rent space and share resources in such a facility. This would reduce costs substantially and lessen transportation problems. A survey of individual plating firms indicated considerable interest in such a facility. Similar projects have been successful abroad. A potential for the production of cogenerated electricity and process steam is projected at the industrial park, thereby greatly reducing energy costs for the participants.

A key facet of the study[2] completed under Work Effort 12 was examination of the resource recovery concept--recycling and reclamation of the valuable metals used in the electroplating process. This should make Cleveland the model for compliance by other industrial areas and serve as the "working model" for new technology as it becomes available.

Platers who send their wastes to the Resource Recovery Park will benefit from reduced costs of treatment through economies of scale. Platers who relocate to the Park will benefit from these savings and in addition will have the opportunity to renovate their operations, share utility expenses, and substantially reduce their cost of energy. The analyses which follow include only the benefits of reduced waste treatment costs.

As discussed in the Work Effort 12 report, there are a variety of configurations that exist or could be used for a central treatment system. Figure 1 presents one of the configurations most applicable to highly industrialized areas. In the example system, the area represented is an industrialized metropolitan area typical of those found in the midwest and northeast. The industrialized sectors of the city are located outside the central business district. The central processing facility is also located outside the central business district and away from residential areas. However, the facility must be located close enough to industry to allow economical waste hauling. Also, the central facility must be sited close to major transportation routes that allow truck transport. Waste hauling through the business district and residential areas should be minimized.

The site for ultimate disposal of unrecoverable residuals will generally have to be located at some distance from the central processing facility. Although it would be convenient to

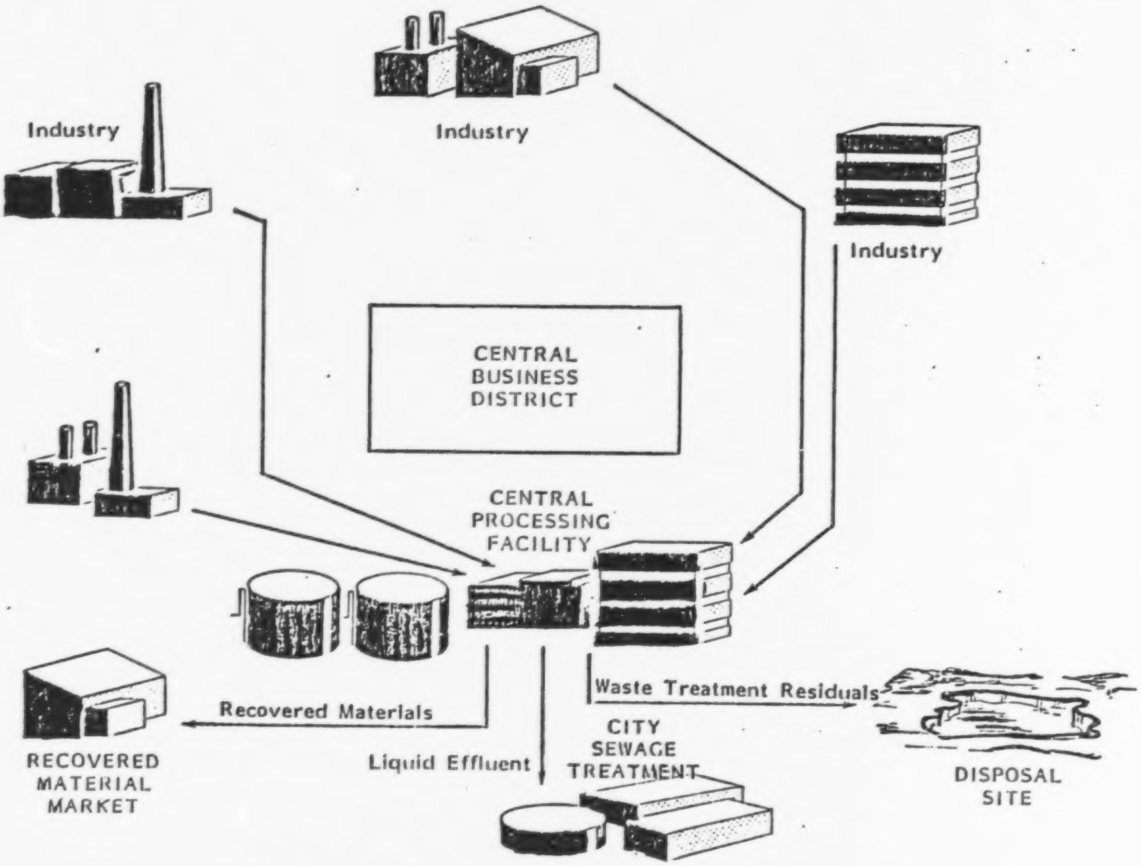
Industry
Industry
Industry
CENTRAL BUSINESS DISTRICT
CENTRAL PROCESSING FACILITY
Waste Treatment Residuals
Recovered Materials
Liquid Effluent
CITY SEWAGE TREATMENT
RECOVERED MATERIAL MARKET
DISPOSAL SITE

Figure 27. Central Treatment System Overview

locate the disposal site next to the central processing facility from a siting standpoint, this would be impossible in most metropolitan areas. The major obstacle in disposal siting is the public's refusal to allow industrial waste to be discarded near residential and business sectors. Also, the disposal area for waste treatment residuals may require a large tract of land which would be very expensive within the metropolitan area. Therefore, the disposal site, in most instances, must be located at least 10 miles outside the metropolitan area.

During operation, industrial wastes would be collected from participants either on an as-needed basis or according to a set schedule. The waste would be transported by trucks using major highways and usually circumventing residential and business areas. The waste would be delivered to the central facility and processed. Any recovered materials would be shipped to appropriate markets, residual solids (usually sludge) would be sent to the disposal site. The treated liquid effluent from the central processing would be discharged to the city sewer system.

Figure 2 illustrates the layout of a typical central processing facility. The facility site would be secured by fencing to prevent unwanted entry. Within the site there would be an administrative office, analytical laboratory and a building containing waste processing equipment. The waste receiving area would be located at the perimeter of the process building.

During operation, trucks hauling waste would enter the central facility site and be received by a plant operator. The waste hauler would identify his waste by customer and waste type. The operator would take a sample of the waste for analysis and assign the waste to a receiving dock. Waste analysis would be performed as necessary to determine if the nature of the accepted waste is as stated by the hauler.*

The waste is either dumped into receiving pits or directly pumped to the appropriate storage tank. There it will be mixed with similar waste and enter the appropriate treatment process. In the illustrated example (Figure 2) Waste A receives a preliminary process step then is combined with Waste B and the unrecovered portion of Waste C. This mixture is then treated and the liquid effluent flows to a retention tank. This tank provides protection against the discharge of improperly treated

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*If the waste is hazardous as defined by EPA (40CFR261), then a complete analysis of the waste must be available or performed before treatment.

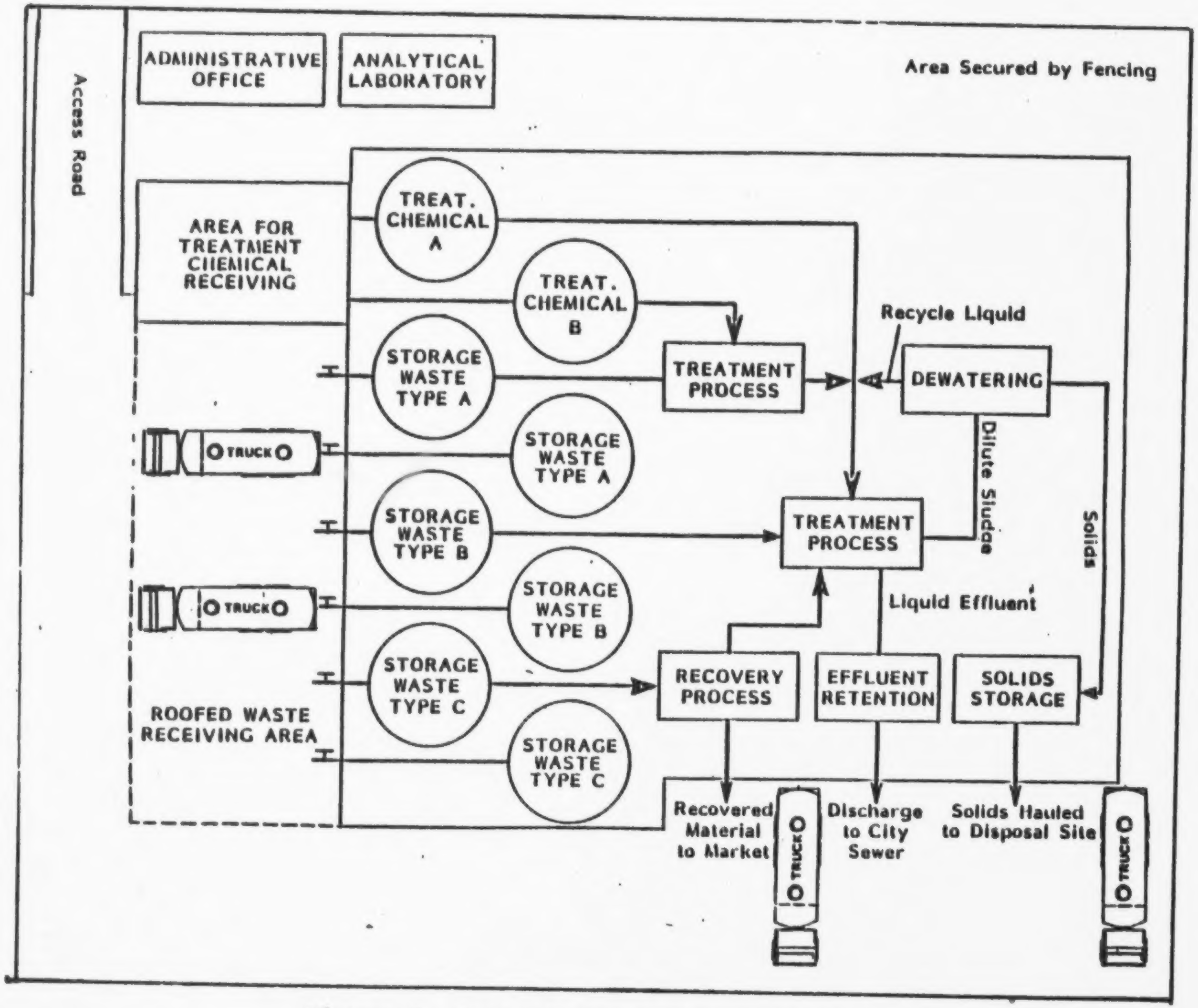
Access Road
ADMINISTRATIVE OFFICE
ANALYTICAL LABORATORY
Area Secured by Fencing
AREA FOR TREATMENT CHEMICAL RECEIVING
TREAT. CHEMICAL A
TREAT. CHEMICAL B
STORAGE WASTE TYPE A
STORAGE WASTE TYPE A
STORAGE WASTE TYPE B
STORAGE WASTE TYPE B
STORAGE WASTE TYPE C
STORAGE WASTE TYPE C
TRUCK
TRUCK
ROOFED WASTE RECEIVING AREA
TREATMENT PROCESS
Recycle Liquid
DEWATERING
Dilute Sludge
Solids
TREATMENT PROCESS
Liquid Effluent
RECOVERY PROCESS
EFFLUENT RETENTION
SOLIDS STORAGE
Recovered Material to Market
Discharge to City Sewer
Solids Hauled to Disposal Site
TRUCK
TRUCK

Figure 2. Central Processing Facility

effluent. The dilute sludge from the treatment process goes to dewatering to reduce the volume of waste requiring transport to the disposal site. The liquid from dewatering is usually contaminated with pollutants and is returned to the treatment process. The dewatered solids are stored in a tank to await shipment to the disposal site.

Individual waste generators would participate in a CWT system by first concentrating their wastes as much as possible before transport to the central facility. For electroplaters this can be achieved by either utilizing innovative rinsing techniques (e.g., series rinsing, still rinsing) or through application of a technology such as ion exchange. In the latter case, ion exchange equipment could be leased and serviced by the central facility management. Instead of sending concentrated rinsewaters, the ion-exchange cylinders would be transported to the central facility where they would be regenerated for treatment or recovery.

The initial design of the Resource Recovery Park has been based on the latter concept described above whereby all dumps requiring treatment from all of the Cleveland electroplaters are shipped to the Resource Recovery Park for disposal. In addition, all running rinses requiring treatment are serviced by in-plant ion exchange modules leased to the plater by the Resource Recovery Park. When these modules require regeneration, they are trucked back to the Resource Recovery Park, where regeneration followed by treatment of the regenerant and disposal of residuals takes place. The potential for recovery of useful metal values is enhanced by the use of ion exchange, since the regenerant under certain conditions can be returned to the plating tank.

The Resource Recovery Park has been sized in the WE-12 report both on the assumption that all platers included in the analysis would decide to take part, and for a reduced capacity with "30 plant" participants. The second design has been used as the basis for the analyses presented herein because the marketing study (Section 4) shows that the required capacity, based on expected participation, approaches the "30-plant" design.

This report presents the proposed management and organizational plan. The marketing analysis, the financing strategy, and the expected operating results are described in detail.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

The proposed Resource Recovery Park, as a step toward the reindustrialization of Cleveland, is a viable financial undertaking. Over 55 firms within Cleveland city limits would find it to their benefit to participate. Other customers outside of the initial base of Cleveland electroplaters could be expected to join. Potential for additional economic benefit, not quantified here, based on recovered resource value and cogeneration of power and heat also exists.

A financial structure consisting of 22 percent equity, 78 percent long term borrowings is recommended. Projected discounted cash flow return to the equity investors is over 60 percent for a 15-year horizon.

While the debt instrument considered here has been conventional corporate debentures, it is recommended that the availability of tax exempt industrial revenue bonds, with or without SBA guarantee, be explored. Leveraged lease financing should also be considered. The critical conclusion, based upon the "30 plant" participants scenario, is that the RRP of Cleveland is a viable financial undertaking. The principal recommendation is to proceed with the resource recovery park centralized treatment facility. Ownership and management by a single private corporation is shown to be the preferred structure, although other arrangements are possible.

SECTION 3

MANAGEMENT

OWNERSHIP

The managerial control of the Resource Recovery Park will be somewhat dependent on the specific ownership plan implemented. Three possible ownership combinations have been considered and are presented here:

- Private ownership. In the case of private ownership, the complete managerial control, operational liability, and financial responsibility will rest with a private firm. In general, this option will preclude any local government or industry user participation in control of the facility, selection of clients, or determination of fees. This option does, however, have the advantage of freeing the individual industries from liability and minimizing the economic impact on the individual industries by absolving them from capital outlays. In addition, the establishment of a privately owned centralized treatment facility and RRP would expand the state and municipal tax base. This is the expected type of ownership for the Cleveland Resource Recovery Park.

- Government ownership of the land with private ownership and management of the facility. In some urban areas, the high cost of land acquisition would necessitate high treatment costs to clients, making the RRP unattractive from an economic viewpoint. Governmental assistance in the form of dedicated land, which could be leased below market value or at a token rate, would relieve a significant portion of the financial burden from the RRP owner, thus allowing the employment of economically attractive treatment fees. The liability incurred by the government from the land dedication would be minimal, as would their voice in the control and policies regarding the facility.

- Government ownership of the land and the facility with private management. In this case, the government would assume all ownership related liabilities including responsibility for the design, construction, and controlling authority. A government owned facility would most likely fall under the control of the local Public Owned Treatment Works (POTW). The government would be in control of treatment fees as well as managerial policies. The private management organization would function primarily to carry out the governmental decisions and oversee the day to day operations while maintaining only a limited voice in the decision making process.

GENERAL MANAGEMENT STRUCTURE

Although the controlling authority will vary by ownership, as indicated, the general management structure will remain as specified herein. At the onset of the project, a management committee, acting as a board of directors or trustees, will be established for the purpose of planning, directing, and controlling the facility. The committee will be established by mutual agreement of the participating entities. Within the committee, the controlling authority will be designated by percentage ownership of the facility. A chairman will be appointed within the committee to preside over the committee functions. These functions will include, but not be limited to, six major items.

- Accepting new clients. Only the committee may decide to accept a new client's waste for treatment. A careful study of the client's waste must be performed to ensure that it contains no elements which are untreatable at the facility. The committee must also evaluate the volume of the client's waste with respect to the treatment plant capacity and future plans. The entire authority, responsibility, and legal liability associated with accepting a new client rests with the committee.

- Approving plant expansions and modifications. Any plant expansions or modifications may seriously affect the capacity and/or ability to treat clients' waste as well as having a potential impact on treatment fees. For this reason, all expansion or modification plans must be evaluated and approved by the committee before implementation.

- Approving the plant budget. The committee will be responsible for reviewing and approving the plant budget. If necessary, the committee will suggest revisions to the budget. Revisions will be reviewed with the plant manager, although the committee maintains final authority.

- Determining treatment fees. As time progresses, treatment fees will require revision to account for varying treatment costs as well as plant expansions or modifications. The fee adjustment will be closely tied to the plant budget and will be evaluated a minimum of once per year.

- Establishing employee salary and benefit programs. The committee will be responsible for providing salary guidelines for all personnel employed at the facility and will be directly responsible for the salary and performance reviews of the plant manager. In addition, the committee will be responsible for establishing, and periodically reviewing, a comprehensive benefits program for the employees of the facility.

- Staffing of project manager/plant manager position. The individual to act as project manager/plant manager will be interviewed, selected, and hired by the committee. In all directing and controlling activities, the committee will act through the project manager/plant manager.

The project manager selected by the committee will be responsible for the overall management of the construction of the facility. Responsibilities of the project manager will include, but not be limited to, four management functions.

- Interface between the committee and construction company. The project manager will be responsible for all construction aspects of the facility and will report progress regularly to the committee. Any modifications of construction plans initiated by the committee will be implemented by the project manager. In addition, the project manager is responsible for ensuring that construction of the facility is carried out on schedule and within the specified budget.

- Hiring and training plant personnel. As construction of the facility progresses, it will be the responsibility of the project manager to hire supervisors, operators, and other plant personnel in accordance with the salary and policy guidelines established by the committee. Upon hiring the personnel, the project manager also has the responsibility for training the personnel.

- Plant startup. Upon completion of construction, the project manager will be responsible for the treatment plant startup. He will be responsible for all scheduling and coordination of activities and operations as well as ensuring that all federal, state, and local compliance regulations are met.

- Assume position of plant manager following startup. Following successful plant startup, the project manager will assume the position and associated responsibilities of plant manager. In this capacity, he will be responsible for plant operations and other specific responsibilities detailed in the position description provided later in this report.

OPERATING STRUCTURE

The operating structure described herein reflects projected personnel requirements after resource recovery and cogeneration are fully incorporated into the operation of the Resource Recovery Park. While the financial analysis of Section 5 considers the treatment function only and is based on an 8 hour-per-day, 5-day-per-week schedule, the manpower needs presented here envision operation 24 hours per day, 7 days per week.

Personnel requirements and scheduling on shifts for operating the plant 24 hours per day, 7 days per week, are listed in Table 1.

The organizational structure of the personnel is presented in Figure 3. Specific qualifications and responsibilities associated with each position are listed in Table 2. The number of required personnel may be trimmed if the hours of operation are cut to 5 days per week or to less than three shifts per day.

MARKETING, CONTRACTUAL, AND LEGAL ASPECTS

Certain marketing practices and policies will be adhered to during operation of the treatment facility RRP. As a part of these established policies, all clients will be classified as either contract clients or open market clients. As the name implies, contract clients will be bound by a long term agreement for the treatment of their waste at the RRP facilities. To ensure the continuance of a firm base of consistent clients, inducements will be offered in the form of reduced treatment costs and preferential acceptance of waste for long-term contract clients. It is expected that all of the plating shops within the marketing base will be accepted on this basis.

Open market clients, solicited on a temporary or irregular basis, will benefit the treatment facility by allowing it to run at a more efficient capacity. Open market clients' waste, however, will require more comprehensive analysis since it is

TABLE 1. PERSONNEL LIST AND GENERAL SHIFT SCHEDULING ASSUMING 24 HR/DAY OPERATION

Day Shift Only	People Per Shift	Total People
Plant Manager	1	1
Chemist	1	1
Administrative Assistant/ Bookkeeper	1	1
Laborer	1	1
Lab Technician	1	1
Standard Rotating Shift		
Shift Supervisor	1	4
Operator	1	4
Security Guard	1	4
	Total	17

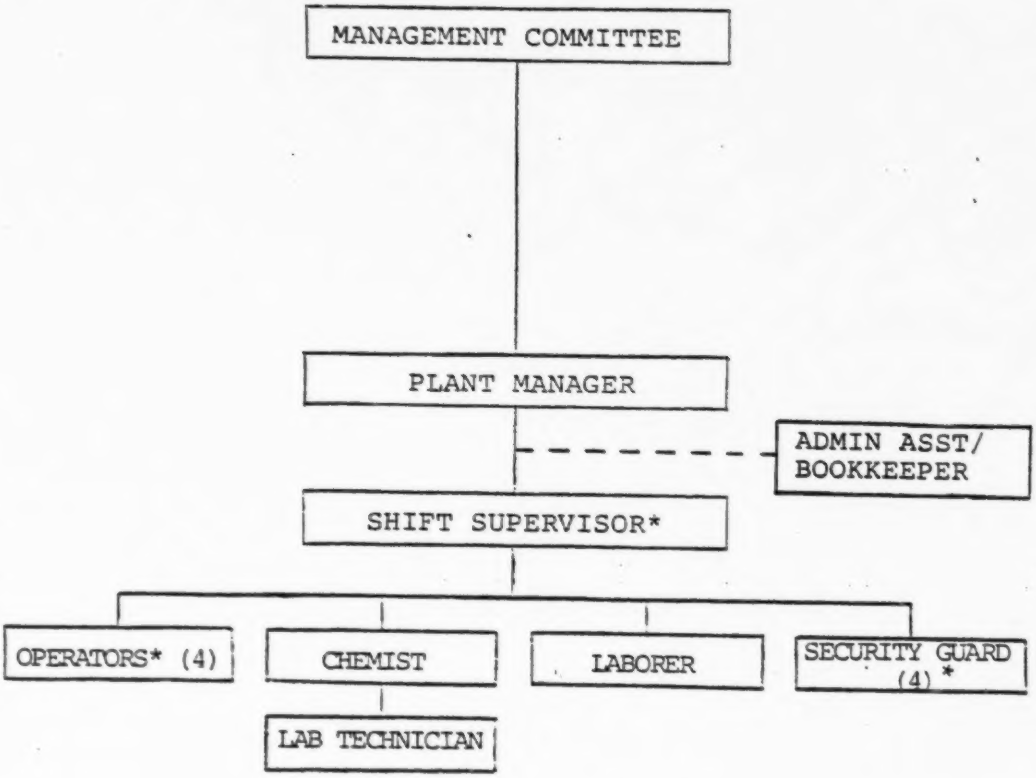
MANAGEMENT COMMITTEE
PLANT MANAGER
ADMIN ASST/ BOOKKEEPER
SHIFT SUPERVISOR*
OPERATORS* (4)
CHEMIST
LABORER
SECURITY GUARD (4) *
LAB TECHNICIAN

Figure 3. Operating Structure for 30 Plant Treatment Capacity
*Indicates Rotating Shift

TABLE 2. PERSONNEL QUALIFICATIONS

Position	Minimum Qualifications	Responsibilities
Plant Manager	B.S. Degree in Chemical Engineering or a related field plus 5 years' experience in the chemical or waste treatment industry with at least 2 years of that including environmental work. Project management experience desired	Liaison with management committee Liaison with regulatory agencies, clients, and media Responsible for: Quality assurance Plant safety Control of all manifests, permits, documentation and procedures Personnel policies and staffing Coordinating all operations Plant budget Overall scheduling Contract services Hiring/firing of plant personnel
Shift Supervisor	H.S. Diploma plus 5 years'chemical plant experience, at least 2 years of which included supervising people	Substitutes for plant manager when required Authority to suspend waste unloading Responsible for: Day-to-day operations and maintenance All modifications, improvements, and troubleshooting Operational documentation Waste acceptance All spill reports All accident reports Treatment chemical and product inventories Plant security Daily scheduling of personnel and treatment Inventory of spare parts and tools Safety inspections
Chemist	B.S. Degree in Chemistry plus 3 years' industrial experience	Responsible for: Lab procedures and techniques Timely sampling and analysis Documentation of samples and analyses Determination of waste compatibility Lab instrumentation and reagent inventory

(continued)

TABLE 2 (continued).

Position	Minimum Qualifications	Responsibilities
Chemist (cont'd)		Lab technicians First aid station Safety inspections
Operator	H.S. Diploma plus 2 years' chemical plant experience	Responsible for: Proper control of processes Routine maintenance work Additional minor repairs and maintenance Timely reporting of spills or process upsets Documentation of operating parameters Area housekeeping
Lab Technician	H.S. Diploma plus 2 years' chemistry-related experience	Responsible for: Timely sampling and proper documentation of samples Sample analysis and documentation Manning first aid station Area housekeeping
Laborer	References indicating good performance at a location for 2 years just prior to application	Responsible for: Timely unloading of waste trucks Loading of product or sludge trucks General plant maintenance and housekeeping
Security Guard	H.S. Diploma, 2 years' experience with good references	Responsible for: Plant security Traffic control Operation of vehicle scale Documentation of vehicle weights Safety briefing of truck drivers and visitors Emergency communications
Administrative Asst/Bookkeeper	Business School, 2 years' experience with good references, excellent typing, accounting skills	Responsible for: Maintaining document and operating log files Acting as receptionist General secretarial duties Bookkeeping, billing, accounts receivable, accounts payable

not accepted on a regular basis. The open market clients' waste may at times be refused if treatment plant problems or high volumes of contract clients' waste do not allow sufficient capacity to treat the open market waste.

In order to ensure that treatment facility upsets are minimized, allowable ranges of various constituents in the waste, and volume restrictions, will be stipulated in each client contract. The Plant Manager will have authority to set these limits based on treatability of the client's waste and the plant treatment capacity. In addition, in each contract, a provision will be made for the assessment of additional charges, or total refusal of treatment, for waste which fails to meet the aforementioned composition and/or volume criteria as deemed necessary by the management commitee. This option for refusal is essential to protect the operating personnel, whose safety may be at stake, and the plant manager, who bears a legal responbility to ensure that the plant does not release harmful materials to the environment.

In order to guarantee the continuous operability of the facility, it is imperative to ensure that the opportunity always exists to dispose of metals which may be recovered and/or sludge which may result from the treatment of the waste. To accomplish this, customer contact will be consistently maintained with at least one alternate purchaser and/or disposer of the treatment products. As much as possible, preference will be given to those clients who wish to purchase reclaimed metals; however, a consistent and reliable avenue of disposal must always be maintained. This may require a constant, but low volume service with the alternate purchaser or disposal service, which would take priority over resale to clients. This condition will be outlined in the client contracts.

An alternate source of treatment chemicals shall be established by periodic contact with the alternate source to maintain an awareness of supply and availability. Periodic purchases from the alternate source will allow a determination of the consistency of quality of the chemicals, and the effect on the treatment process of a reagent from a different source. In addition, periodic purchases will establish a rapport as a client with the supplier to ensure prompt service or delivery in a critical situation.

Transportation and distribution of waste and treatment products will be controlled by the management committee of the RRP treatment facility. The management committee will evaluate local trucking services and will negotiate open-ended contracts with three reputable and reliable firms. The contracts with the firms will specify the type of truck to be used for hauling specific types of wastes, and the procedure for cleaning the trucks between loads. The committee will present a list of the three selected firms to the plant manager, who will be responsible for controlling all waste hauling using the approved firms. Periodically, the management committee will review the assessment of additional fees to clients causing shipping delays and make an evaluation as to whether a client should be eliminated or penalized in some manner for impairing operation of the facility.

The majority of licensing and regulatory issues for plant operations will be handled by the plant manager. He will be responsible for the daily interface and documentation required by regulatory and enforcement agencies. In addition, he will handle the conventional renewal of permits and licenses and report on such renewals and periodic inspections to the management committee. The plant manager will be responsible for maintaining an awareness of regulations pertinent to the facility and will periodically present to the management committee a report on newly promulgated regulations and their expected effect on plant operations. Any initial licensing of new facilities, expansions, or modifications must be approved by the management committee. Liabilities resulting from mishandling of hazardous materials extend to both the management committee and the plant manager.

PERMITS, LICENSES, EASEMENTS

The proposed Resource Recovery Park will apply for all required federal, state, and local permits. The permits will be for construction and environmental discharges. Construction permits will include plumbing, electrical, site, and building permits. These permits will be obtained solely from the city of Cleveland. Once a site has been selected that is properly zoned for the purpose, no problems are anticipated in obtaining the necessary building permits. Environmental permits will be obtained from the U.S. EPA according to procedures established under the Resource Conservation and Recovery Act (RCRA), the Clean Water Act, and the Clean Air Act. The Resource Recovery Park will seek permits as both storage and treatment facilities, as defined by RCRA, so that the Resource Recovery Park may have flexibility in its operations. Applications will also be submitted to the city of Cleveland's Division of Air Pollution and Division of Water Pollution Control. The Ohio EPA will also review the facility's permit applications. No problems are anticipated in obtaining these permits. Such application should be made as early as possible.

When a site for the RRP is selected, easements upon the park should be investigated and evaluated. Required licenses should be obtained.

INSURANCE

The Resource Recovery Park will seek to obtain insurance through an insurance company that regularly provides business insurance. Insurance will be obtained to cover:

1. Fire and other similar emergencies on buildings, equipment, and all other owned, used, or stored property. Included in this category would be losses caused by lightning, wind, or hail storms, floods, automobile accidents, explosions, earthquakes, and similar occurrences.

2. Public liability, including bodily injury and property loss or damage, on all operations such as those involving automobiles, elevators, bailee's charges, or any company function carried on at a location away from the plant premises.

3. Business interruptions.

4. Power-plant, machinery, and special operations hazards.

5. Workmen's compensation.

6. Marine and transportation insurance on all property in transit.

7. Comprehensive crime coverage.

8. Employee benefit insurance.

APPLICABLE DESIGN CODES, SAFETY STANDARDS, AND PHYSICAL SECURITY OF THE PLANT

All applicable design codes and safety standards will be incorporated into the design of the Resource Recovery Park. Although most of the plant equipment does not operate under conditions of extreme pressures or temperatures, those items of equipment that fit into this category will be designed according to proper codes and standards. These will include standards of the American Society of Mechanical Engineers (ASME) and American National Standards Institute (ANSI). ASME standards are nationally accepted for the design of pressure vessels. ANSI codes B31.1 and B31.3 will establish the minimum standards acceptable for pressurized and non-pressurized piping used in the RRP. Nonpressurized vessels will be designed in accordance with the nationally accepted standards of the American Petroleum Institute. Electrical work and equipment will be required to meet National

Electrical Manufacturers Association (NEMA) standards, as a minimum requirement.

Safety standards will be incorporated into the plant design from sources such as the National Fire Protection Association (NFPA), the Occupational Safety and Health Act (OSHA), the National Institute of Occupational Safety and Health (NIOSH), and the Resource Conservation and Recovery Act (RCRA). Safety standards in RCRA can be found in Sections 264.36, Section 265.17 and Part 265, Subparts I, J, K, and L as applicable. These parts in RCRA describe physical storage of hazardous wastes and materials in order to provide safe separation and storage of non-compatible materials. NFPA codes describe design practices to insure a relatively safe operating environment to both prevent and minimize fire hazards. OSHA and NIOSH standards are designed to prevent occupational accidents and to prevent worker injury or damage to health should accidents occur.

Physical security of the plant, as described in RCRA, Section 264.14, will be used to set minimum standards. Additional security measures will be implemented as required by the location of the plant, and the needs of the community.

ENVIRONMENTAL IMPACT

No adverse environmental impacts are anticipated under normal operating conditions. It will be management's intent to operate the facility so that it reduces the environmental impact of waste being treated.

Treated liquids normally discharged by the plant will meet or surpass all current environmental safety standards. During abnormal operating conditions, spills, leaks, and the plant effluent will be confined and stored for subsequent treatment.

Hazardous solid waste (as defined by RCRA) leaving the plant will be disposed of at a legally operated hazardous waste landfill. Other solids, considered to be safe will be disposed of using appropriate conventional methods.

Under normal operating conditions, there will be a very small amount of pollutants emitted into the atmosphere in concentrations expected to be well within current standards. These polluants come from evaporation of chemicals used and stored in the plant, such as chlorine and cyanide compounds.

SECTION 4

INCENTIVES FOR PARTICIPATION--WASTE TREATMENT

COSTS ASSOCIATED WITH NON-PARTICIPATION

While it has been noted that over 100 platers are in operation in the Cleveland area, the present marketing study has excluded those outside of city limits. Of the 76 platers remaining, 30 were visited and 5 of those were intensively studied, including wastewater sampling and analysis. Results of such investigations have been used to characterize the operations of all of the 76 plants considered.[2]

Table 3 presents the annual costs for each plant should it decide to meet its pollution control requirements individually rather than through participation in the Resource Recovery Park. The annual costs for most plants are substantial. Moreover, considerable capital investment is required if the non-participation route is taken. The estimates of capital and operating costs for in-plant pretreatment are taken from Reference 2.

The first column of the table presents the plant identification number as coded in the previous CENTEC study.[2] The next two columns present the investment costs and annual operating costs associated with required wastewater treatment equipment of the nature described in Reference 2. For most plants the cost associated with sludge handling and disposal has been calculated based on an assumed rate of $.50 per gallon. Those few plants in Cleveland found to generate over 150 gallons per day of sludge will find it economical to invest in sludge dewatering equipment. An investment cost for such equipment was assigned for those plants.

A capital recovery factor (CRF) was used to annualize the wastewater and sludge investment. A cost of funds of 20 percent and an equipment life of 10 years were used for this purpose. These annualized investment costs when added to the operating costs result in the total annual costs associated with wastewater treatment and sludge disposal, respectively. The last column of Table 3 presents the sum of the annual costs for wastewater treatment and for sludge disposal.

TABLE 3. COSTS OF ON-SITE TREATMENT

PLANT ID #	WW TRTMT INVEST	WW OP COSTS	SLUDGE INVEST COST	SLUDGE OP COST	TOTAL ANNUAL COSTS FOR ONSITE TRMT
1	116000.00	13700.00	0.00	9000.00	50366
2	95000.00	15900.00	0.00	5300.00	43858
3	0.00	9300.00	0.00	2600.00	11900
4	75000.00	34700.00	0.00	12500.00	65088
5	60000.00	14000.00	0.00	1438.00	29748
6	167000.00	13400.00	0.00	2080.00	55310
7	118000.00	23700.00	30000.00	7600.00	66598
8	53000.00	9300.00	30000.00	7700.00	36796
9	125000.00	15900.00	30000.00	8900.00	61768
10	12000.00	2200.00	0.00	100.00	5162
12	35000.00	15000.00	0.00	2900.00	26248
13	12000.00	2200.00	0.00	4400.00	9462
14	143000.00	21000.00	30000.00	10100.00	72361
15	60000.00	27700.00	0.00	11232.00	53242
16	33000.00	9300.00	0.00	2600.00	19771
17	104000.00	20000.00	0.00	11300.00	56104
18	12000.00	2200.00	0.00	200.00	5262
19	12000.00	2200.00	0.00	6000.00	11062
20	53000.00	11200.00	0.00	2400.00	26241
21	12000.00	2200.00	0.00	0.00	5062
22	91000.00	12000.00	0.00	9100.00	42804
23	12000.00	2200.00	0.00	8500.00	13562
24	12000.00	2200.00	0.00	500.00	5562
25	57000.00	11600.00	0.00	2400.00	27595
26	70000.00	18300.00	0.00	13800.00	48795
27	95000.00	17200.00	0.00	7300.00	47158
28	50000.00	11600.00	0.00	2600.00	26125
30	12000.00	2200.00	0.00	300.00	5362
31	294000.00	98400.00	90000.00	31700.00	221684
32	56000.00	9500.00	0.00	8100.00	30956
33	118000.00	14200.00	0.00	12500.00	54843
34	92000.00	12000.00	0.00	8400.00	42342
36	12000.00	2200.00	0.00	4900.00	9962
37	101000.00	12900.00	0.00	11400.00	48389
38	26000.00	6000.00	0.00	1600.00	13801
39	33000.00	9300.00	0.00	2600.00	19771
40	36000.00	8000.00	0.00	5400.00	21986
42	95000.00	15500.00	0.00	3000.00	41158
43	0.00	9300.00	0.00	2600.00	11900
44	113000.00	12300.00	0.00	11300.00	50551
45	91000.00	15000.00	0.00	2100.00	38804
48	33000.00	9300.00	0.00	2600.00	19771
49	246000.00	76800.00	75000.00	26400.00	179759
50	101000.00	13200.00	30000.00	12500.00	56944
52	0.00	9300.00	0.00	2600.00	11900
53	0.00	9300.00	0.00	2600.00	11900
55	170000.00	21200.00	30000.00	8700.00	77600
58	33000.00	10200.00	0.00	800.00	18871
59	26000.00	6700.00	0.00	5400.00	18301
60	19000.00	5400.00	0.00	2600.00	12532
61	26000.00	6600.00	0.00	2100.00	14901
62	116000.00	13400.00	0.00	6600.00	47666
63	38000.00	9300.00	0.00	2600.00	20963
64	33000.00	9300.00	0.00	2600.00	19771
66	33000.00	9300.00	0.00	2600.00	19771
67	53000.00	9200.00	0.00	5600.00	27441
69	26000.00	6400.00	0.00	2400.00	15001
71	33000.00	9300.00	0.00	2600.00	19771
72	133000.00	17200.00	30000.00	7800.00	63876
73	476000.00	87000.00	90000.00	33400.00	255391
74	33000.00	9300.00	0.00	2600.00	19771
76	26000.00	6000.00	0.00	4100.00	16301
TOTAL	4417000.00	920700.00	465000.00	397650.00	2482707.00
MINIMUM	0	0.00	0.00	0.00	0.00
MAXIMUM	476000.00	98400.00	90000.00	33400.00	255391.00
AVERAGE	70111.11	14614.29	7380.95	6311.90	39408.05

COSTS OF JOINING THE RESOURCE RECOVERY PARK

The Resource Recovery Park will provide ion exchange modules to all plants that have running rinses requiring treatment. The modules will be transported to the Resource Recovery Park when they require regeneration, and fresh modules will be left in their place. Batch dumps will be transported to the Resource Recovery Park for treatment in 55-gallon containers. Ion exchange modules will be leased to plants requiring them at a rate which allows the Resource Recovery Park to recover its investment over the expected useful life of the modules.

Tables 4 and 5 present the derivation of the RRP fee structure as presented in Tables 31 and 34 of Reference 2. The fees calculated for each RRP capacity (76 plant and 30 plant) allow recovery of investment in 10 years with a 20 percent cost of funds. A profit of 10 percent of all costs is also included. As has been discussed in Section 3, a minimal staff appropriate to initial single shift, 5 day per week operation is considered.

Linear interpolation between the two plant capacities in order to determine the variation of fee with capacity may be accomplished by the relation:

$$\text{Fee (\$/gal)} = .176 - .7 \times 10\text{-}8 \times \text{Capacity (gal per year)}$$

This relation has been used in a computer model designed to determine the projected customer base of the RRP under a variety of assumptions.

Table 6 presents the expected decision of each plant based on economic incentives. Given specified costs for transportation, rental of the ion exchange modules, on-site treatment (annualized), and the relation between fee and total annual RRP volume, each plant owner will make his decision.

The first three columns of Table 6 show the plant ID, its annual volume of batch dumps requiring treatment, and its annual requirement for ion exchange modules to treat its running rinses. The next column shows the investment each plant owner accepting ion exchange modules would have to make in pumps and hoses in order to connect its rinses to the system.

Batch dump volume, column 2, was obtained through plant survey for plants 1-30 as described in Reference 2. In order to estimate the volume of batch dumps at the remainder of the Cleveland plants, a relation between total wastewater flow and batch dump volume was developed. A correlation coefficient of .815 between total flow and batch dump volume was found using data from 25 shops. Relations were obtained by linear regression.

TABLE 4. FEE DETERMINATION--76-PLANT CONFIGURATION

8 JANUARY 1982
ION EXCHANGE OPTION ALL PLANTS
76 PLANT CONFIGURATION

FACILITY NAME	CLEVELAND RESOURCE RECOVERY PARK
PREPARED FOR	INFORMATION
PREPARED BY	CENTEC
ANNUAL PRODUCTION	10,537,083
UNITS OF PRODUCTION	GALS OF WASTEWATER
CAPITAL COSTS ($)	1,560,714

COST ITEMS	QUANTITY	RATE ($)	TIME	ITEM COST	UNIT COST
SALARIES & WAGES:					
PLANT MANAGER	1.00 MANYEAR	@ 32,000.00		32,000	0.003
SECRATARY	1.00 MANYEAR	@ 12,000.00		12,000	0.001
OPERATOR	1.00 MANYEAR	@ 20,000.00		20,000	0.002
CHEMIST	1.00 MANYEAR	@ 25,000.00		25,000	0.002
				----------	-------
TOTAL SALARIES & WAGES				89,000	0.008
ASSOCIATED OVERHEAD		@ 58.00 %		51,620	0.005
UTILITIES:					
ELECTRICITY	119.40 KWH	@ 0.07	250 DAY	2,090	0.000
WATER	6,672.00 CU FT	@ 0.01	250 DAY	24,520	0.002
				----------	-------
TOTAL UTILITIES				26,609	0.003
CHEMICALS:					
CAUSTIC	4,250.00 LB	@ 0.14	250 DAY	148,750	0.014
SO2	765.70 LB	@ 0.11	250 DAY	21,057	0.002
H2SO4	553.49 LB	@ 0.04	250 DAY	5,535	0.001
POLY-E	5.06 LB	@ 2.50	250 DAY	3,161	0.000
				----------	-------
TOTAL CHEMICALS				178,503	0.017
PERCENT OF CAPITAL COST ITEMS:					
MAINTENANCE		@ 6.00 %		93,643	0.009
INSURANCE		@ 2.00 %		31,214	0.003
CAPITAL RECOVER		@ 23.80 %		371,450	0.035
				----------	-------
TOTAL PERCENT OF CAPITAL COST ITEMS				496,307	0.047
OTHER COSTS:					
HAUL/DISPOSAL	1,095.00 GAL	@ 0.50	250 DAY	136,875	0.013
				----------	-------
TOTAL OTHER COSTS				136,875	0.013
SUBTOTAL				978,914	0.093
PROFIT		@ 10.00 %		97,891	0.009
				==========	=======
TOTAL COST				1,076,805	0.102

TABLE 5. FEE DETERMINATION--30-PLANT CONFIGURATION

```
                               8 JANUARY 1982
                       ION EXCHANGE OPTION ALL PLANTS
                           30 PLANT CONFIGURATION

FACILITY NAME               CLEVELAND RESOURCE RECOVERY PARK
PREPARED FOR                INFORMATION
PREPARED BY                 CENTEC
ANNUAL PRODUCTION              6.482.916
UNITS OF PRODUCTION         GALS OF WASTEWATER
CAPITAL COSTS ($)              1,373.891

 COST ITEMS          QUANTITY          RATE ($)        TIME      ITEM COST UNIT COST
--------------     -----------       ----------    ---------- ---------- ---------
SALARIES & WAGES:
PLANT MANAGER         1.00 MANYEAR   @ 32,000.00
SECRATARY             1.00 MANYEAR   @ 12,000.00                  32,000     0.005
OPERATOR              1.00 MANYEAR   @ 20.000.00                  12,000     0.002
CHEMIST               1.00 MANYEAR   @ 25,000.00                  20.000     0.003
                                                                  25,000     0.004
  TOTAL SALARIES & WAGES                                      ----------   -------
  ASSOCIATED OVERHEAD                @       58.00 %              89,000     0.014
                                                                  51.620     0.008
UTILITIES:
ELECTRICITY          119.40 KWH      @        0.07     250 DAY
WATER              4,049.00 CU FT    @        0.01     250 DAY     2.090     0.000
                                                                  14.880     0.002
  TOTAL UTILITIES                                             ----------   -------
                                                                  16,970     0.003
CHEMICALS:
CAUSTIC            2.371.00 LB       @        0.14     250 DAY
SO2                  353.70 LB       @        0.11     250 DAY    82,985     0.013
H2SO4                336.60 LB       @        0.04     250 DAY     9,727     0.002
POLY-E                 3.11 LB       @        2.50     250 DAY     3,366     0.001
                                                                   1,944     0.000
  TOTAL CHEMICALS                                             ----------   -------
                                                                  98,022     0.015
PERCENT OF CAPITAL COST ITEMS:
MAINTENANCE                          @        6.00 %
INSURANCE                            @        2.00 %              82,433     0.013
CAPITAL RECOVER                      @       23.85 %              27,478     0.004
                                                                 327,673     0.051
  TOTAL PERCENT OF CAPITAL COST ITEMS                         ----------   -------
                                                                 437,584     0.067
OTHER COSTS:
HAUL/DISPOSAL        602.90 GAL      @        0.50     250 DAY
                                                                  75.363     0.012
  TOTAL OTHER COSTS                                           ----------   -------
                                                                  75.363     0.012
  SUBTOTAL
  PROFIT                             @       10.00 %             768.558     0.119
                                                                  76.856     0.012
  TOTAL COST                                                  ==========   =======
                                                                 845.414     0.130
```

TABLE 6. COST OF RRP PARTICIPATION

PLANT ID #	VOLUME OF DUMPS GPY	IX MODULES PER YEAR	IN-PLANT COSTS	TOTL ANNUAL COSTS OF PARTICPN	ON SITE - RRP PARTIC COST	NO OF SHOPS JOINING
1	6960.00	657.00	2400.00	34717.52	15648.48	1.00
2	2563.00	59.00	800.00	3746.46	40111.04	1.00
3	5200.00	0.00	0.00	1313.06	10586.94	1.00
4	55200.00	10434.00	3200.00	529059.02	0.00	0.00
5	3380.00	84.00	1600.00	5375.97	24372.03	1.00
6	9631.00	368.00	2400.00	21145.36	34164.14	1.00
7	2773.00	108.00	800.00	6215.01	60382.99	1.00
8	29875.00	1889.00	800.00	100855.20	0.00	0.00
9	16640.00	795.00	2400.00	43964.71	17802.79	1.00
10	520.00	0.00	0.00	131.31	5030.69	1.00
12	867.00	0.00	0.00	218.93	26028.57	1.00
13	13286.00	44.00	2400.00	6096.29	3365.71	1.00
14	20800.00	1158.00	2400.00	62909.70	9450.80	1.00
15	1600.00	94.00	1600.00	5419.47	47822.53	1.00
16	5073.00	50.00	800.00	3936.60	15833.90	1.00
17	845.00	245.00	800.00	12481.76	43622.24	1.00
18	347.00	0.00	0.00	87.62	5174.38	1.00
19	9100.00	123.00	1600.00	8742.89	2319.11	1.00
20	10400.00	442.00	3200.00	25178.26	1062.24	1.00
21	358.00	0.00	0.00	90.40	4971.60	1.00
22	7150.00	445.00	3200.00	24505.49	18298.01	1.00
23	2167.00	0.00	0.00	547.19	13014.81	1.00
24	650.00	0.00	0.00	164.13	5397.87	1.00
25	750.00	74.00	1600.00	4218.91	23375.59	1.00
26	3840.00	177.00	2600.00	10315.18	38479.82	1.00
27	8840.00	501.00	2400.00	27502.02	19655.48	1.00
28	5200.00	100.00	1600.00	6624.28	19500.72	1.00
30	5073.00	0.00	0.00	1280.99	4081.01	1.00
31	28600.00	9086.00	4000.00	456081.66	0.00	0.00
32	9919.00	138.00	800.00	9498.34	21457.66	1.00
33	5092.00	113.00	1600.00	7237.86	47605.14	1.00
34	6738.00	84.00	800.00	6033.10	36308.90	1.00
36	3037.00	9.80	800.00	1440.78	8521.22	1.00
37	6814.00	35.00	800.00	3636.78	44751.72	1.00
38	2118.00	30.00	800.00	2204.51	11596.49	1.00
39	13060.00	84.00	1600.00	7820.28	11950.22	1.00
40	3032.00	128.00	800.00	7266.33	14719.67	1.00
42	2551.00	29.00	800.00	2264.55	38892.95	1.00
43	17278.00	0.00	0.00	4362.88	7537.12	1.00
44	2143.00	221.00	1600.00	11817.20	38733.30	1.00
45	2307.00	100.00	1600.00	5893.77	32909.73	1.00
48	1904.00	50.00	800.00	3136.39	16634.11	1.00
49	48166.00	2885.00	1600.00	154763.76	24994.74	1.00
50	3272.00	3994.00	1600.00	198097.09	0.00	0.00
52	14053.00	0.00	0.00	3548.53	8351.47	1.00
53	4856.00	0.00	0.00	1226.19	10673.81	1.00
55	4393.00	1168.00	2400.00	59259.72	18340.28	1.00
58	2026.00	150.00	2400.00	8478.43	10392.07	1.00
59	12707.00	172.00	800.00	11878.41	6422.59	1.00
60	1954.00	100.00	800.00	5613.83	6917.67	1.00
61	2105.00	35.00	800.00	2447.70	12453.30	1.00
62	5650.00	30.00	1800.00	3334.87	44331.13	1.00
63	2312.00	50.00	800.00	3239.42	17723.58	1.00
64	3509.00	50.00	800.00	3541.67	16228.83	1.00
66	45902.00	50.00	800.00	14246.36	5524.14	1.00
67	5118.00	35.00	800.00	3208.52	24231.98	1.00
69	14123.00	300.00	800.00	18545.89	0.00	0.00
71	4460.00	50.00	800.00	3781.81	15988.69	1.00
72	16721.00	476.00	800.00	27878.05	35997.45	1.00
73	50824.00	6559.00	2400.00	336740.20	0.00	0.00
74	5663.00	50.00	800.00	4085.58	15684.92	1.00
76	1933.00	128.00	800.00	6988.83	9312.17	1.00
TOTAL	583428.00	44236.80	77200.00	2346443.03	1124740.54	56.00
MINIMUM	0.00	0.00	0.00	0.00	0.00	
MAXIMUM	55200.00	10434.00	4000.00	529059.02	60382.99	
AVERAGE	9260.76	702.17	1245.16	37245.13	17853.02	

Flow >10,000 gpd:

Dump vol (gpy) = 485 + 0.19 Flow (gpd)

Flow $\leq$10,000 gpd:

Dump vol (gpy) = 1,682 + .105 Flow (gpd)

Annual transportation costs for each plant were calculated based on the parameter values given below:

Cost of truck operation	$27/hour
Time required per pickup	4 hours
Modules per truckload	30
55-gallon drums per truckload	20

The rental costs for the modules have been calculated based on recovery of capital investment over the expected 10 year life at an assumed cost of funds of 20 percent (CRF = .2385). In addition, the expenses of maintenance and insurance (8 percent of the investment), and replacement of resin (one-tenth of the resin cost each year) are included in the rent. The annual rental fee is then $439 for an anion unit and $228 for a cation unit as shown in Reference 2.

All in-plant investment (both to install ion exchange if participating or to install treatment if not participating) has been annualized. By using the same 10 year life and 20 percent cost of funds factors, the participating and nonparticipating plants are compared.

The sum of annual transportation costs, treatment costs, ion exchange rental, and annualized ion exchange installation costs, is shown as the total annual cost of participation in column five of Table 6. The difference between the annual cost of onsite treatment (Table 2) and these total costs of participation is given in the next column (zero if negative).

It may be seen that all except the six largest shops are projected to find incentives for participation sufficient. Those that are projected not to participate have such large flows of wastewater that transportation and module rental fees make participating uneconomical.

The total wastewater to be treated at the RRP annually given the decision pattern shown in Table 5 is 3,045,864 gal/yr. This is somewhat less than the flow for the "30-plant" design case of Reference 2. (The 30 plants were selected to include most of the large plants.) As discussed in Section 3, open market customers are expected to increase the customer base. Therefore, the financial analyses presented herein are based on the 30-plant design.

Figure 4 presents the projected number of customers and the wastewater flow as a function of the trucking hourly rate at several values of the cost of funds to the individual shops. Figure 5 shows the sensitivity of the decision of the plating shops to the rental fee charged for the ion exchange modules.

This analysis of incentives has assumed that platers will install on site treatment when that approach is less costly than shipment of wastes to the RRP. However, experience has shown that many will choose to avoid the installation of treatment equipment within the plant even when that choice leads to somewhat higher costs. Because of such aversion to on site treatment, these plants will utilize the RRP unless the savings to be obtained by investment in treatment equipment are sufficiently great. Table 7 shows results to be expected for different levels of demanded savings expressed as a percentage of the capital investment.

This marketing analysis shows that a solid base of participation can be expected for the RRP. Nearly all shops find incentives for participation sufficient, and that conclusion is relatively insensitive to variation in values of the various parameters.

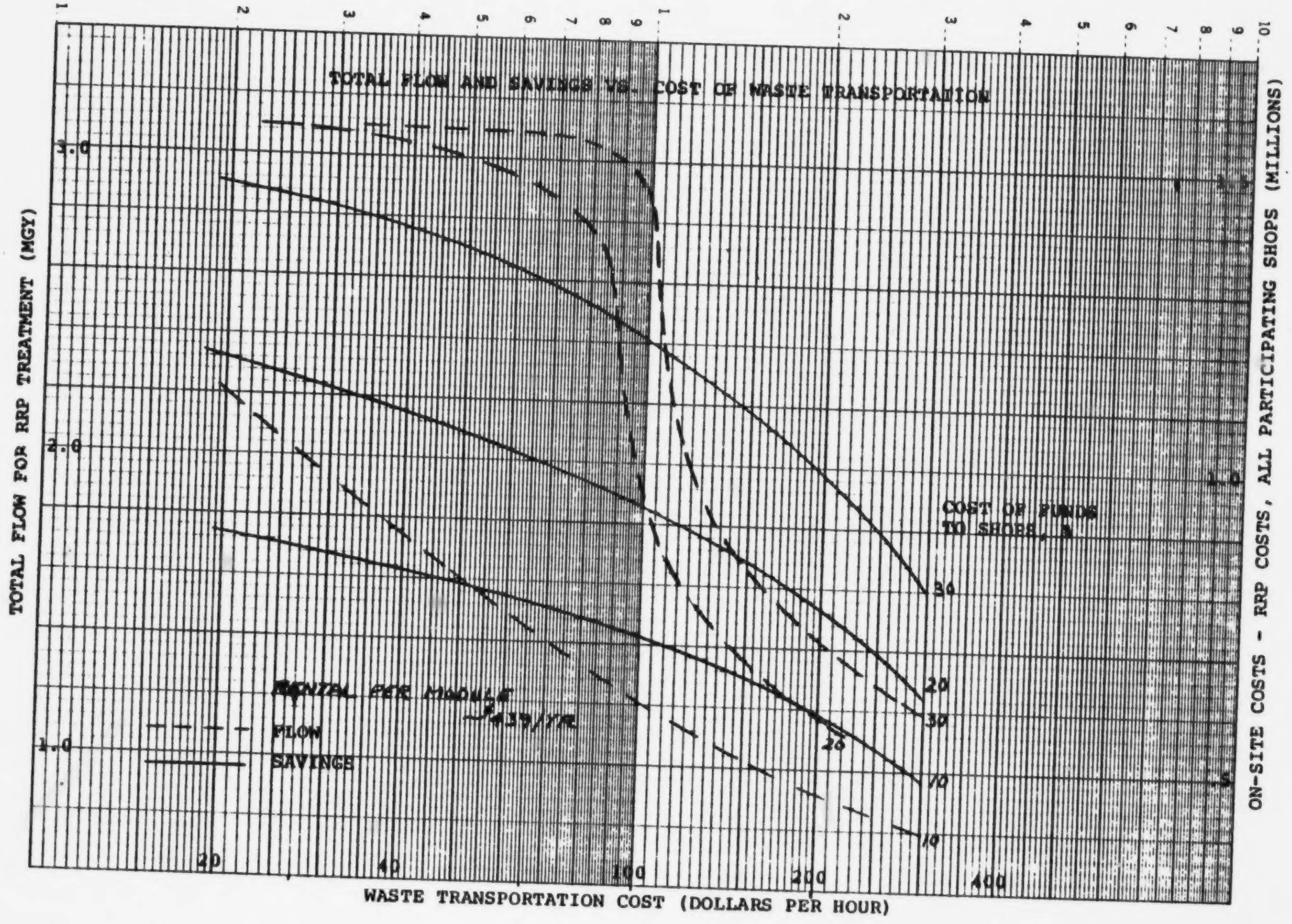

Figure 4. Total Flow and Savings vs. Cost of Waste Transportation

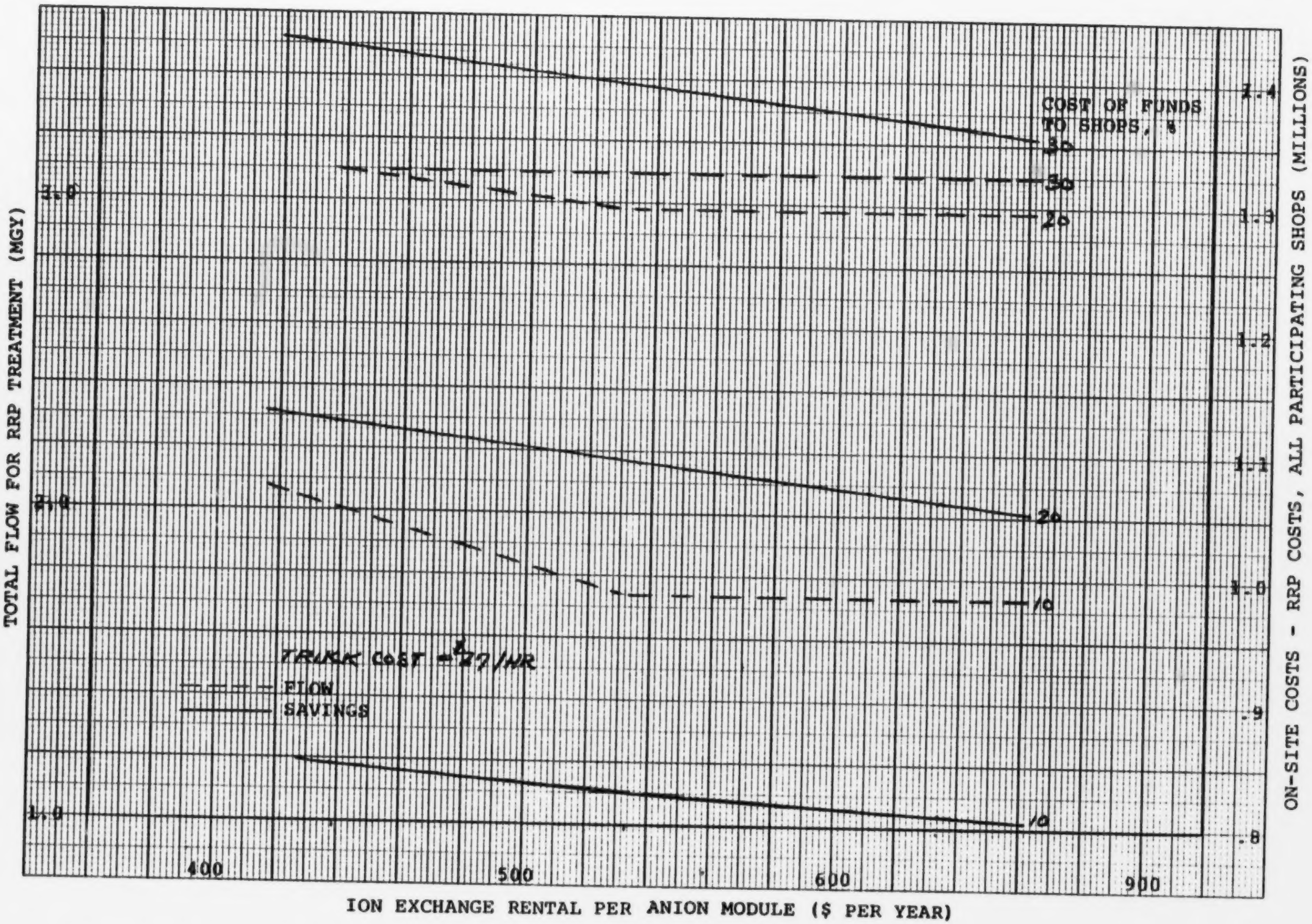

Figure 5. Total Flow and Savings vs. Ion Exchange Rental Fee

TABLE 7. EFFECT OF AVERSION TO ON-SITE TREATMENT

Annual RRP Flow in Gal/yr
(No. of Shops Participating)

Savings* as a Percent of Capital Investment	Cost of Funds to Individual Shops, %		
	10	20	30
0	2,007,373 (53)	3,095,865 (56)	3,095,865 (56)
20	3,095,864 (56)	4,237,605 (58)	4,237,605 (58)
40	4,237,605 (58)	4,237,605 (58)	4,237,605 (58)
60	4,237,605 (58)	6,281,955 (59)	6,706,980 (60)

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*It is assumed that the specified level of savings must be achieved before a plant will invest in on-site treatment equipment.

SECTION 5

FINANCIAL STRUCTURE

OWNERSHIP

The most feasible arrangement for the Cleveland Resource Recovery Park (RRP) is for the facility to be owned and managed by a single, private corporation. With this arrangement, the complete managerial control, operational liability, and responsibility for obtaining financing will rest solely with the corporate owner. This structure will preclude any local government or industry user participation in control of the facility, selection of clients, or determination of fees. Individual industries, however, will benefit from this arrangement by absolution from treatment liabilities and capital outlays, thus minimizing the economic impact on the industries.

REQUIRED INVESTMENT

Two cases, a facility to treat waste from 30 plants and a facility to treat waste from 60 plants, were presented in the engineering report (Reference 2) to illustrate 2 possible scenarios and the effects of treatment facility size as related to the associated treatment costs. The following financial analyses, however, focus solely on the 30 plant treatment capacity case. This is done for the two following reasons:

- The 30 plant case capacity and associated investment cost more closely approximates the actual size of a facility as dictated by the projected level of industrial user participation (Section 4).
- More accurate data, based on actual plant surveys, was vailable for the development of the 30 plant case study.

The total capital plus start-up costs required to undertake the project amount to $2,136,706. Working capital required for the first year of the project amounts to $148,233. The working capital, however, is treated separately and assumed to be financed in a revolving account on a short term basis, unlike the capital and start up expenses.

EQUITY TO DEBT RATIO

The amount of equity required to acquire financing for the remaining project cost is generally 10 percent to 40 percent of the total project cost. The equity required will vary greatly depending on the method of financing sought, the credit of the party seeking financing, the risk associated with the venture, and the amount of funds available through various loan programs.

Obtaining a loan guarantee on the debt is helpful in keeping the required percentage of equity as low as possible in light of other factors. A guarantee of 90-100 percent of the aggregate amount to be financed generally makes most institutions more willing to provide longer term, lower interest financing in larger amounts and with slightly less restrictions regarding the borrower's credit status. Similarly, a guarantee will increase the marketability and reduce the required interest rate for the issuance of corporate bonds. Guarantees are expensive, however. A 100 percent loan guarantee from the Small Business Administration (SBA) currently costs 3 1/2 percent of the principal plus the interest.

EQUITY STRUCTURE

Under current economic conditions, there are primarily three practical methods for raising the equity portion of the capital required by the private corporation to finance the RRP. The first two methods involve the issuance of shares of stock in the corporation. One way stock may be issued is by public offering. Such an offering requires SEC registration entailing approval procedures which may take as long as nine months. Although there are no restrictions regarding the number of investors or their qualifications, there is a high cost for legal fees associated with the aforementioned approval procedure. This cost, in conjunction with the approval period, makes the second method, private placement of stock, more attractive.

When a private placement of stock is performed, no SEC registration is required, thus avoiding both the associated high legal costs and long waiting period for approval. Participation is limited, however, to 35 investors, and each investor must qualify by having a minimum net worth of $200,000. Although the limited number of investors may be stifling on larger projects, it should not be a significant problem with the cost of the proposed RRP. If 22 percent equity is required, this translates to a minimum investment of approximately $13,500 for each of the 35 investors.

The third available alternative for raising the required equity is to offer limited partnerships. By offering limited partnerships, equity may be raised in exchange for a share in future profits, depreciation, or tax deductions. Various structures exist although the most common arrangement is for the limited partners to initially receive a large share of the profits or other items, with their share declining over the life of the project.

The amount of equity contributed by a limited partner provides the maximum limit on the liabilities of that partner. This type of equity structure, because it requires profit sharing, would be an attractive method for raising equity only if difficulties were encountered in using the private placement stock method.

DEBT STRUCTURE

The general latitude in attractive debt financing alternatives has become rather limited due to changes in tax laws, fluctuating interest rates, and other economic factors. As of January 1982, due to action by the Office of Management and Budget, previously tax exempt industrial revenue bonds (IRB's) are now taxable. Thus, SBA guaranteed IRB's, including the Special Pollution Control Revenue Bonds (PCRB's), no longer provide an advantage over other financing methods, and are being discontinued.*

Three methods remain as the most feasible means of debt financing. These methods are (1) conventional industrial mortgage financing, (2) corporate bond issuance, and (3) leveraged lease financing.

Conventional industrial mortgage financing is a method by which a long term loan is secured by the collateral of fixed assets. The leverage (ratio of debt to equity) achievable by this method is limited by the collateral liquidation value of the borrower's credit. The interest associated with such a loan is generally at the prime rate, which is currently 15-16 percent.

The primary qualifying requirement of adequate collateral to cover the lender's margin requirements and satisfy the lender's credit needs may preclude the use of this type of financing method for the RRP unless a 100 percent loan guarantee is obtained. An SBA loan guarantee, pledging the full faith and credit of the U.S. Government to 100 percent of the amount loaned, may be purchased for 3 1/2 percent of the principal plus interest. In addition to the high cost of the guarantee, extensive processing procedures are required[3] and the borrower must meet the following SBA qualifications:[3]

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*First Wisconsin Bank of Milwaukee, personal communication with Mary Beth Steffens,Jan. 1982.

(1) The small business[3] must have been in operation for a minimum of five years and profitable in at least three of the last five years.

(2) The small business must be at an operational or financing disadvantage as compared with similar business concerns with respect to the planning, design, or installation of pollution control facilities *OR* the *obtaining of financing* for such facilities.

(3) The small business concern should have or be able to get certification from its state or local regulatory authority that its project, when completed and operational, will reduce, abate, or control pollution.

(4) The business must be qualified as small by either having less than a maximum number of employees for a given industry classification *or* with all affiliates, the business must have a net worth less than or equal to $6 million and an average annual after-tax income for the previous two years less than or equal to $2 million.

Corporate bond financing entails public marketing of bonds by the corporation rather than by the state or municipality. These bonds are not tax exempt and thus are issued at a rate very near the prime rate. The success of such a bond issue is largely a function of the bond's marketability, which is in turn strongly related to the corporate credit image. The marketability of the bonds may therefore be enhanced by purchasing a guarantee very similar to that stipulated for the conventional mortgage.

There is essentially no interest incentive associated with the bond method of financing. It does provide a vehicle for financing projects when a corporation cannot meet the collateral requirements for a conventional industrial mortgage.

The third debt financing alternative is leveraged lease financing, a type of sale-leaseback transaction. This is generally structured in a three party format with a lessor, a senior lender, and a lessee. While there are several variations on this format, in the most likely arrangement for this project the lessor subordinates his investment to the lien of the senior lender and in turn receives tax incentive benefits [investment tax credits and accelerated cost recovery system (ACRS) allowances] with a very limited (highly leveraged) outlay of funds, generally 10 percent of the adjusted basis of the property. The senior lender receives a normal return on the secured loan with sufficient equity furnished by the lessor and repayments from the lessee's payments. At the end of the term the lessee generally purchases the facility for a token sum and has, over the length of the term, essentially financed the project with no equity required on his part.

This is a very soundly conceived structure for a project with demonstratable cash flow for repayments, providing that special tax advantages are ensurable to the lessor, and that credit criteria are satisfactory to the lessor and senior lender. In addition, the financing may be set up and closed within a relatively short period of time, usually within 45 days, and there is little risk to the lessor. Although there is a high degree of leverage and low debt servicing cost associated with his method of finance, tax incentives to the lessee are lost, there is a lack of equity buildup for the lessee, and the initial legal expenses to structure the program may be large.

This is an attractive arrangement under current tax laws. However, Congress may soon repeal the specific tax laws which make the arrangement so attractive.

SELECTED FINANCIAL PACKAGE FOR FURTHER ANALYSIS

Based on the information presented, the most attractive and probable financial package for the Cleveland RRP is to raise equity through private placement of shares and to finance the debt by the issuance of corporate bonds. A discounted cash flow (DCF) analysis follows assuming that 22 percent of the total capital plus startup costs will be raised as equity and the remaining 78 percent financed through issuance of corporate bonds at 17 percent interest. The DCF analysis calculates the annual discount rate at which the net cash in-flows exactly balance the invested funds outflow over the life of the project.

Table 8 presents the results of the DCF analysis indicating a DCF rate of return of 62.8 percent, an average percent return on investment of 24.6 percent, and a payback period on the total investment of 7.8 years. Since the DCF rate of return is equivalent to the interest rate that would have to be received on the invested capital to be as attractive as the investment under analysis, this rate of return for the proposed project is very attractive indeed.

Table 9 presents data used as input for the analysis. Table 10 presents the annual cash flow statement. Table 11 shows calculations of selected quantities used as input data.

TABLE 8. DISCOUNTED CASH FLOW ANALYSIS

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                         DISCOUNTED CASH FLOW ANALYSIS
                            RESOURCE RECOVERY PARK
                                 15 MAR 1982
PROJECT: CLEVELAND RRP; 30 PLANTS; CORP BONDS
TOTAL CAPITAL + STARTUP COST $ 2,136,706
BORROWED CAPITAL AT 17%      $ 1,666,631
DCF RATE OF RETURN (%)             62.76
AVE % RETURN ON INVESTMENT         24.56
PAYBACK YEARS FOR TOTAL INVESTMENT  7.8
```

TABLE 9. DCF INPUT DATA SUMMARY REPORT

```
*** 1 *** GENERAL DESCRIPTION
CASE DESCRIPTION
DEPRECIATION METHOD (SL/SD/DB/ND/AR/AS)   = CLEVELAND RRP; 30 PLANTS; CORP BONDS
DATE                                      = AR
TAX CREDIT & LOSS CARRY FORWARD? (Y/N)    = 15 MAR 1982
COMPANY NAME                              = N
                                          = RESOURCE RECOVERY PARK

*** 2 *** PROJECT COST & LIFE
BASE YEAR FOR CAPITAL OUTLAY
CAPITAL COST FOR REAL PROPERTY ($)        =         1981
CAPITAL COST FOR PERSONAL PROPERTY ($)    =       58,596
  YEARS     COST
    3      38,270
    5   1,684,680
   10     255,160
STARTUP COSTS ($)
LIFE OF PROJECT (YEARS)                   =      100,000
                                          =           15

*** 3 *** GROSS INCOME
GROSS INCOME FOR FIRST YEAR ($)
   YEARS   ESCALATION OF GROSS INCOME (%) =    1,151,035
   2 - 16      10

*** 4 *** LABOR, MAINT., UTILITIES & MATERIALS
OPERATING LABOR ($)
LABOR OVERHEAD RATE (%)                   =       89,000
ESCALATION OF LABOR (%)                   =           58
MAINTENANCE (% OF CAPITAL COST)           =           10
ESCALATION OF MAINTENANCE (%)             =            6
UTILITIES AND MATERIALS COST ($)          =           10
   YEARS   ESCALATION OF UTILITIES & MATERIALS (%)250,468
   2 - 16      10

*** 5 *** RESEARCH, SALES, AND G&A
RESEARCH EXPENSES ($)
ESCALATION OF RESEARCH EXPENSES (%)       =            0
SELLING EXPENSES ($)                      =            0
ESCALATION OF SELLING EXPENSES (%)        =            0
GENERAL & ADMINISTRATIVE EXPENSES ($)     =            0
ESCALATION OF G&A (%)                     =            0
                                          =            0

*** 6 *** TAXES AND INSURANCE
TAXES AND INSURANCE (% OF CAPITAL COST)   =            2
ESCALATION OF TAXES AND INSURANCE (%)     =           10
INVESTMENT TAX CREDIT RATE (%)            =           10
CAPITAL COST ELIGIBLE FOR TAX CREDIT (%)  =           97
CORPORATE TAX RATE (%)                    =           48

*** 7 *** FINANCING METHOD
LONG-TERM LOAN (% OF TOTAL INVESTMENT)
INTEREST ON LONG-TERM LOAN (%)            =           78
LOAN PAYBACK PERIOD (YEARS)               =           17
BALLOON PAYMENT (% OF LOAN)               =            7
CONSTRUCTION LOAN (% OF LOAN)             =            0
CONSTRUCTION LOAN INTEREST (%)            =            0
INTEREST PAID ON WORKING CAPITAL (%)      =            0
   YEARS   WORKING CAPITAL (DAYS OF SALES/YR)         17
   1 - 15     43.7
```

TABLE 10. CASH FLOWS BY YEAR

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
GROSS INCOME	-470,075	1,151,035	1,266,139	1,392,752	1,532,028	1,685,230	1,853,753	2,039,129	2,243,042	2,467,346	2,714,080	2,985,488	3,284,037	3,612,441	3,973,685	4,371,053	36,101,163
OPERATING COST	0	554,024	609,427	670,370	737,407	811,147	892,262	981,488	1,079,637	1,187,601	1,306,361	1,436,997	1,580,697	1,738,766	1,912,643	2,103,907	17,602,733
LOAN PRINCIPAL	0	141,576	165,644	193,803	226,749	265,297	310,397	363,165	0	0	0	0	0	0	0	0	1,666,631
LOAN INTEREST	0	283,327	259,259	231,100	198,153	159,606	114,506	61,738	0	0	0	0	0	0	0	0	1,307,690
WORKG CAPTL INT	0	23,753	26,128	28,741	31,615	34,777	38,254	42,080	46,288	50,916	56,008	61,609	67,770	74,547	82,001	90,202	754,688
CASH FLOW (BT)	-470,075	148,355	205,681	268,739	338,103	414,404	498,334	590,658	1,117,117	1,228,829	1,351,712	1,486,883	1,635,571	1,799,128	1,979,041	2,176,945	14,769,422
STARTUP - DEPR	0	20,000	20,000	20,000	20,000	20,000	0	0	0	0	0	0	0	0	0	0	100,000
DEPRECIATION-AR	0	284,635	424,801	402,468	383,205	383,205	29,423	26,870	26,871	26,871	26,870	3,907	3,907	3,906	3,907	3,907	2,034,753
TAXABLE INCOME	0	-14,705	-73,477	40,073	161,648	276,495	779,309	926,952	1,090,246	1,201,958	1,324,841	1,482,976	1,631,664	1,795,222	1,975,134	2,173,038	14,771,375
INCOME TAX	0	-7,058	-35,269	19,235	77,591	132,718	374,068	444,937	523,318	576,940	635,924	711,829	783,199	861,707	948,064	1,043,058	7,090,260
TAX CREDIT	0	190,588	0	0	0	0	0	0	0	0	0	0	0	0	0	0	190,588
PROFIT (AT)	0	182,942	-38,208	20,838	84,057	143,777	405,241	482,015	566,928	625,018	688,917	771,148	848,465	933,515	1,027,070	1,129,980	7,871,703
CASH FLOW (AT)	-470,075	346,001	240,950	249,504	260,512	281,686	124,266	145,721	593,799	651,889	715,788	775,054	852,372	937,421	1,030,976	1,133,887	7,869,750
DCF	-470,075	212,590	90,961	57,872	37,127	24,665	6,686	4,817	12,060	8,135	5,488	3,651	2,467	1,667	1,127	761	0

TABLE 11. CALCULATION OF ITEMS IN DCF INPUT, TERMS 1-6

		$
1.	Capital Cost for Real Property: Land	58 596
2.	Personal Property:	
	3 yr ACRS depreciation: Forklift and barrels	38 270
	5 yr ACRS depreciation:	
	Treatment equipment (installed plus startup)	596 865
	Utility hookup	5 000
	Ion exchange modules	762 815
	Engineering	100 000
	Management	100 000
	Contingency	120 000
		1 684 680
	10 yr ACRS depreciation:	
	Building and structure	255 160
	5 yr straight line amortization	
	Start-up cost	100 000
3.	Gross Operating Income	
	Treatment (7779500 units/yr)($.109/unit) =	847 966
	Rental (see following page)	303 069
		1 151 035
4.	Utilities & Materials: Utilities	16 970
	Chemicals	98 022
	Haul/Disposal	75 363
	Resin	60 113
		250 468
5.	Capital Cost Eligible for Tax Credit:	
	3 yr depreciation property	38 270
	5 yr depreciation property	1 684 680
	10 yr depreciation property	255 160
		1 978 110

$$\frac{1\ 978\ 110}{2\ 036\ 706}\ (100) = 97.1\%$$

(Continued)

TABLE 11 (continued).

6. Working Capital (wc):

$$(7779500 \text{ Units/yr}) \ \frac{1 \text{ Yr}}{250 \text{ days}} \ \frac{\$.109}{\text{unit}} = \$3392/\text{day "sales"}$$

$$\text{WC Estimate} \ \frac{\$148\ 233}{\$3392/\text{day "sales"}} = \underline{43.7 \text{ Days Sales}}$$

NOTE: Working capital included no provision for IX resin gradual replacement so WC term "Days Sales" was based only on revenue from treatment.

Breakdown of costs and income for rental of IX modules:

30 Plant Case

Ion Exchange Module Capital Cost	$ 762,815
Cost of Resin	601,125
Life of Resin	10 Yr
Capital Rec. Factor	.2385 of Total Capital
Resin Replac. Factor	.1 of Resin Cost

Rental Fee = $303,069/yr as calculated below:

(capital recovery) + (tax, insur. & maint.) + (resin replacement)

(.2385/yr)($762,815) + (0.08/yr)($762,815) + (0.1/yr)($601,125) = $303,069/yr.

181,931 + 61,025 + 60,113 = 303,069

This will be added to the revenues in the DCF analysis.

Material Cost of Resin

(0.1/yr)($601,125) = $60,113/yr.

SECTION 6

PROJECTED OPERATING RESULTS

Table 12 presents a capital budget for construction of the 30-plant RRP. Table 13 is a statement of the allocation of sources and uses of funds.

It is planned that 78 percent of the required capital will be raised through a placement of long term debt carrying a rate of 17 percent. The proposed loan repayment schedule is shown in Table 14. Table 15 presents a schedule of amortization and depreciation.

Pro forma operating statements for years 1-5 are presented in Table 16. The effect of the first year investment tax credit of $190,588 is not shown in Table 16. It is assumed that investors have income against which operating losses can be applied (thus tax loss carry forward is not employed).

Table 17 presents comparative balance sheets for the start of years 1-5. While losses in the first two years of operations lead to a reduction in equity, the positive cash flow which develops at the start results in a buildup of cash and supplies.

TABLE 12. CLEVELAND RESOURCE RECOVERY PARK
ESTIMATED PROJECT CAPITAL REQUIREMENTS

		$
Structures and Buildings		
	Building	168,660
	Spill Control	15,000
	Paving/Parking	30,000
	Fencing	12,825
	Laboratory	28,675
		$ 255,160
Equipment		
	Treatment Equipment (Installed)	568,865
	Fork Lift and Barrels	38,270
	Utility Hookup	5,000
	Ion Exchange Modules, Anion	745,875
	Ion Exchange Modules, Cation	16,940
		$1,374,950
Other Construction Costs		
	Engineering	100,000
	Management	100,000
	Contingency	120,000
		320,000
TOTAL BASE CAPITAL COSTS		$1,950,110
Other	Organization	100,000
	Land Costs	58,596
	Startup Costs (Equipment)	28,000
	Working Capital	148,233
		$ 334,829
TOTAL PROJECT CAPITAL REQUIREMENTS		$2,284,939

TABLE 13. CLEVELAND RESOURCE RECOVERY PARK
ALLOCATION OF SOURCES AND USES OF FUNDS
($000's)

Uses of Funds	Land and Other	Structures & Buildings	Equipment	Organization	Total
Construction		255.2	1375.0		1630.2
Engineering		15.6	84.4		100.0
Contingency		18.8	101.2		120.0
Land	58.6				58.6
Working Cap.	148.2				148.2
Startup		4.4	23.6		28.0
Organization Costs				100.0	100.0
Project Mgmt.		15.6	84.4		100.0
TOTAL	206.8	309.6	1668.6	100.0	2285.0
Sources of Funds					
Equity	58.6	56.6	304.9	50.0	470.1
Debt		253.0	1363.5	50.0	1666.6
Short term loan	148.2				148.2
TOTAL	206.8	309.6	1668.4	100.0	2285.0

TABLE 14. CLEVELAND RESURCE RECOVERY PARK LOAN REPAYMENT SCHEDULE

Year	Loan Balance	Payment to	
		Principal	Interest
	1,666,631		
1	1,525,055	141,576	283,327
2	1,359,411	165,644	259,259
3	1,165,608	193,803	231,100
4	938,859	226,749	198,153
5	673,562	265,297	159,606
6	363,165	310,397	114,506
7	0	363,165	61,738

TABLE 15. CLEVELAND RESOURCE RECOVERY PARK DEPRECIATION SCHEDULE

ACRS

3 year property	
Forklift and barrels	$ 38,270
5 year property	
Equipment	$1,364,680
Project Engineering	100,000
Project Management	100,000
Contingency	120,000
	$1,684,680
10 year property	
Structures and Buildings	$ 255,160
TOTAL	1,950,110

5 yr Amortization (straight-line)

Start-up Costs	$ 100,000

ACRS Schedule

Year	Depreciation	Accumulated Depreciation
1	284,635	284,635
2	424,801	709,436
3	402,468	1,111,904
4	383,205	1,495,109
5	383,205	1,878,314
6	29,423	1,907,737
7	26,870	1,934,607
8	26,871	1,961,478
9	26,871	1,983,349
10	26,870	2,015,219

TABLE 16. PRO FORMA STATEMENT OF INCOME

	1	2	3	4	5
REVENUES					
TREATMENT FEES	847966.00	932762.60	1026038.86	1128642.75	1241507.02
MODULE RENT	303069.00	333375.90	366713.49	403384.84	443723.32
TOTAL	1151035.00	1266138.50	1392752.35	1532027.59	1685230.34
OPERATING EXPENSE					
CHEMICALS	98022.00	107824.20	118606.62	130467.28	143514.01
UTILITIES	16970.00	18667.00	20533.70	22587.07	24845.78
LABOR	140620.00	154682.00	170150.20	187165.22	205881.74
DISPOSAL	75363.00	82899.30	91189.23	100308.15	110338.97
MAINTENANCE	122202.00	134422.20	147864.42	162650.86	178915.95
RESIN REPLACEMENT	60113.00	66124.30	72736.73	80010.40	88011.44
INSURANCE	40734.00	44807.40	49288.14	54216.95	59638.65
DEPRECIATION	284635.00	424801.00	402468.00	383205.00	383205.00
WORK'G CAP INT'ST	23757.00	26132.70	28745.97	31620.57	34782.62
TOTAL	862416.00	1060360.10	1101583.01	1152231.51	1229134.16
NET INCOME FROM OPRTNS	288619.00	205778.40	291169.34	379796.07	456096.18
OTHER EXPENSE					
AMORTIZATION	20000.00	20000.00	20000.00	20000.00	20000.00
INTEREST	283327.00	259259.00	231100.00	198153.00	159606.00
TOTAL	303327.00	279259.00	251100.00	218153.00	179606.00
BEFORE TAX INCOME	-14708.00	-73480.60	40069.34	161643.07	276490.18
INCOME TAX	-7059.84	-35270.69	19233.28	77588.68	132715.29
NET INCOME	-7648.16	-38209.91	20836.06	84054.40	143774.89

TABLE 17. PRO FORMA 5-YEAR BALANCE SHEET

START OF YR	1	2	3	4	5
ASSETS					
CURRENT					
CASH AND SUPPLIES	107499.00	203861.73	422148.81	732259.99	1057842.79
PREPAID INSURANCE	40734.00	44807.40	49288.14	54216.95	59638.65
ACCTS RECEIVABLE		105512.00	116063.20	127669.52	140436.47
TOTAL	148233.00	354181.13	587500.15	914146.46	1257917.91
LAND	58596.00	58596.00	58596.00	58596.00	58596.00
BLDGS AND EQUIPMENT	1978110.00	1978110.00	1978110.00	1978110.00	1978110.00
LESS ACCUM DEPREC	0.00	284635.00	709436.00	1111904.00	1495109.00
	1978110.00	1693475.00	1268674.00	866206.00	483001.00
ORGANIZATION COSTS	100000.00	100000.00	100000.00	100000.00	100000.00
LESS AMORTIZATION	0.00	20000.00	40000.00	60000.00	80000.00
	100000.00	80000.00	60000.00	40000.00	20000.00
TOT ASSETS	2284939.00	2186252.13	1974770.15	1878948.46	1819514.91
LIABILITIES					
CURRENT					
ACCTS PAYABLE	0.00	31055.83	34161.42	37577.56	41335.31
WAGES PAYABLE	0.00	11718.00	12889.80	14178.78	15596.66
TAXES PAYABLE	0.00	-7060.00	-35271.00	19233.00	77589.00
NOTES PAYABLE	148233.00	163056.30	179361.93	197298.12	217027.94
CUR PORTN LT DEBT	141576.00	165644.00	193803.00	226749.00	265297.00
TOTAL	289809.00	364414.13	384945.15	495036.46	616845.91
LONG TERM DEBT	1525055.00	1359411.00	1165608.00	938859.00	673562.00
OWNERS EQUITY	470075.00	462427.00	424217.00	445053.00	529107.00
	2284939.00	2186252.13	1974770.15	1878948.46	1819514.91

SECTION 7

SAVINGS AVAILABLE THROUGH COGENERATION

This section discusses additional potential benefits of the proposed RRP available to those who relocate there. This aspect of the RRP investment opportunity has not been included in the analyses presented in earlier sections of this report.

CONCEPT OF COGENERATION

Plating plants consume both electrical energy, generally purchased from a public utility, and thermal energy, in the form of process steam, usually generated at the plant site using gas fired boilers. Each of the processes for generating a usable form of electrical or thermal energy has certain inefficiencies associated with it. The goal of cogeneration is to combine steam and electrical generation capabilities into the same facility to boost the efficiency of converting the fuel energy to a usable form and thus save money by reducing the total fuel consumption for a given output.

Cogeneration facilities are of two types: either coal fired boiler with steam turbine/generator, or gas turbine/generator waste heat boiler. Both types require a larger capital investment than conventional boilers which produce only steam; however, the cogeneration capability to conserve fuel often offsets this additional cost. In general, the gas turbine/generator waste heat boiler system is about four times as capital intensive as the coal fired boiler steam turbine/generator system. For this reason, careful analyses are required to select the proper system and size the installation to provide the maximum savings.

ECONOMICS OF COGENERATION FOR THE CLEVELAND RESOURCE RECOVERY PARK

The establishment of a Resource Recovery Park, in which plating shops are located in close proximity, makes the use of a cogeneration facility an attractive method of supplying energy for both the electrical and thermal requirements of the plants. The economics of a cogeneration facility are dependent upon the number of plating plants relocating to the park, and their energy requirements as related to their size.

This section provides estimates of savings resulting from the use of cogeneration for various combinations of small and large plating plants which may relocate to the Resource Recovery Park. Data for the estimates were extracted from a final report titled "Energy Conservation Study of the Plating and Surface Finishing Industry" prepared by The Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia for the Department of Energy.

In addition to the case studies, curves are presented illustrating the relationship between annual savings, cogeneration plant size, and time. These curves graphically depict the increasing savings as energy costs escalate with time, and the increased savings associated with increased plant capacity, reflecting the economies of scale.

A computer program was used to size the cogeneration facility, calculate the gross annual savings, and calculate the installed investment costs.

CONCLUSIONS

The cogeneration analysis has shown that, in all cases investigated, cogeneration using a coal fired boiler and steam turbine/ generator will result in a cost savings when the cogeneration facility is sized for utilization of 100 percent of the thermal energy produced. The use of a gas turbine/generator waste heat boiler system would be unprofitable due to the extremely high capital investment that would be required.

The incremental savings increases linearly with increasing size of participating plating plants as well as with increasing number of participating plating plants. This is illustrated graphically in Figure 6.

Pretax annual savings resulting from cogeneration, considering all cases investigated, fell in the following ranges for individual plants:

Small plating plant	\$5,145 to \$10,226
Large plating plant	\$41,803 to \$50,071

Specific savings for individual plants for each case investigated are presented in Table 18. Savings for the group as a whole for each case investigated are presented in Table 19.

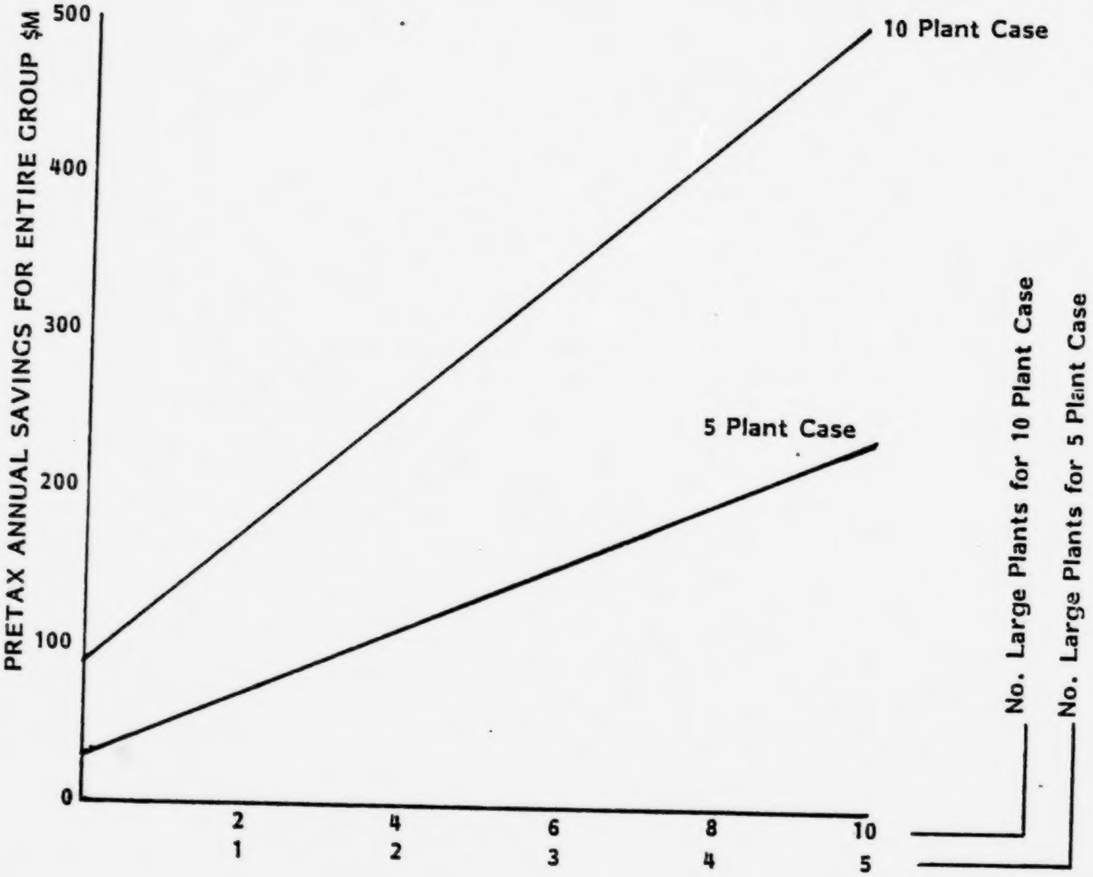


Figure 6. Pre-Tax Annual Savings for Entire Group vs. Number of Large Plants in Group

TABLE 18. SAVINGS FOR INDIVIDUAL PLANTS

Case No.	Description	Individual Plant	Individual Percent of Total Usage	Individual Share of Annual Savings, $
1	Five small plants	Small	20	5,145
2	Three small, two large	Small	7.9	8,696
		Large	38	41,803
3	Five large plants	Large	20	47,130
4	Ten small plants	Small	10	8,087
5	Seven small, three large	Small	4.6	9,655
		Large	22.4	46,412
6	Five small, five large	Small	3.4	10,015
		Large	16.6	48,143
7	Three small, seven large	Small	2.7	10,226
		Large	13.1	49,155
8	Ten large plants	Large	10	50,071

TABLE 19. SUMMARY OF RESULTS FOR ENTIRE GROUP

Case No.	Description	Gross Annual Energy Savings, $	Installed Capital Cost, $	Annualized Installed Capital Cost Over 15 Yr., $	Pretax Annual Savings for Entire Group, $
1	Five small plants	74,630	733,580	48,905	25,725
2	Three small, two large	188,277	1,178,738	78,583	109,694
3	Five large plants	358,747	1,846,475	123,098	235,649
4	Ten small plants	149,260	1,025,909	68,394	80,866
5	Seven small, three large	319,730	1,693,646	112,910	206,820
6	Five small, five large	433,377	2,138,805	142,587	290,790
7	Three small, seven large	577,023	2,583,963	172,264	374,579
8	Ten large plants	717,493	3,251,700	216,780	500,713

Figures 7 through 10 graphically illustrate the increase of pre-tax annual savings as functions of both cogeneration plant capacity and time. These curves reflect the following escalation rates for energy sources: coal, 5%; electricity, 10%; and gas, 20%. Specific data used in the generation of these curves, and the installed capital cost for the various plant capacities are presented in Tables 20 and 21.

DISCUSSION

In sizing the cogeneration facility based upon the available data, several definitions and assumptions were required as follows for the case study analysis:

The quantity of electrical energy consumed was found to have a logarithmic correlation to the plant size as measured by the pounds of anode consumed annually. The thermal energy consumption does not show any direct correlation to plant size. This is attributed primarily to varying values of boiler losses, varying processing methods, and varying energy conservation practices. There is, however, an increased average thermal energy consumption among the larger plants as compared with the smaller plants. Thus the following values were initially determined to describe the plants:

Plant Size	# Anode Consumed Annually	Average Annual Electrical Consumption 10^{10} Btu	Average Annual Thermal Consumption 10^{10} Btu
Small	$\leq$90,000	0.454	2.21
Large	>90,000	1.49	9.68

The quantities specified above were then adjusted for two reasons. First, because a central generation facility will be used for cogeneration, the individual boiler losses will be eliminated. A single boiler loss value is incorporated into the computerized cogeneration calculations. Therefore, the thermal energy consumptions by the small and large plating plants are reduced by their respective average boiler losses, which amounts

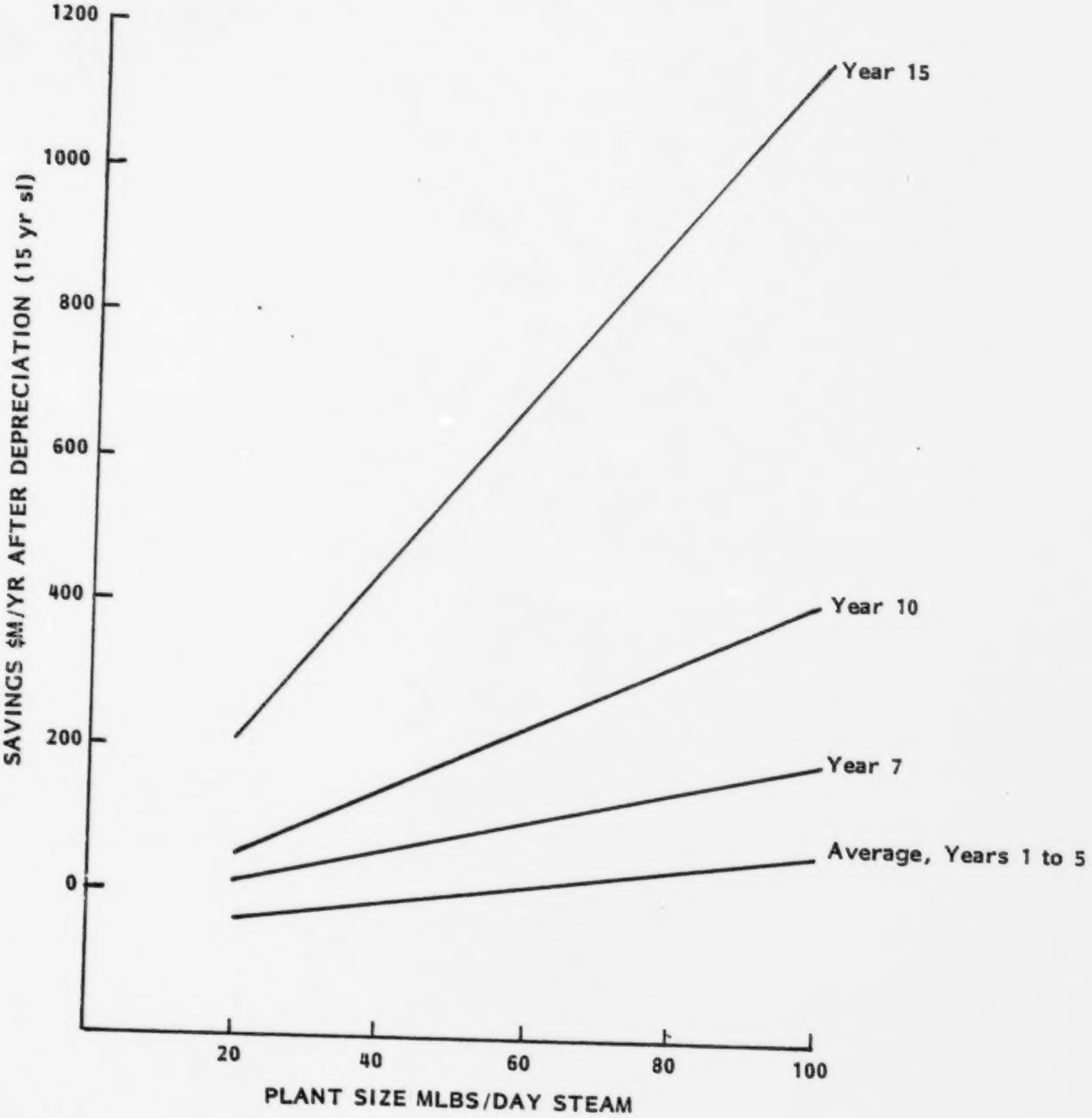


Figure 7. Annual Savings vs. Plant Size

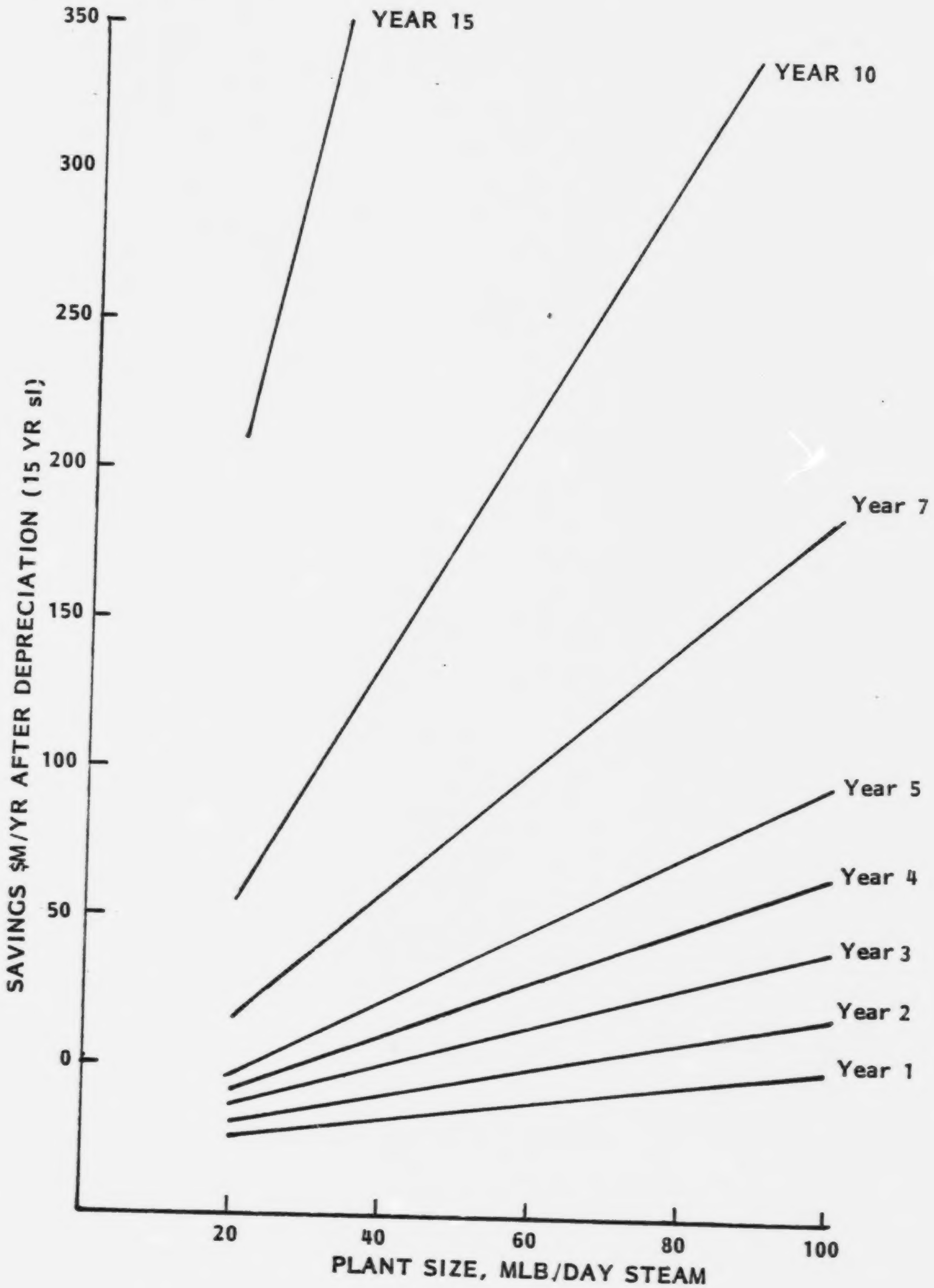


Figure 8. Annual Savings vs. Plant Size (Detail)

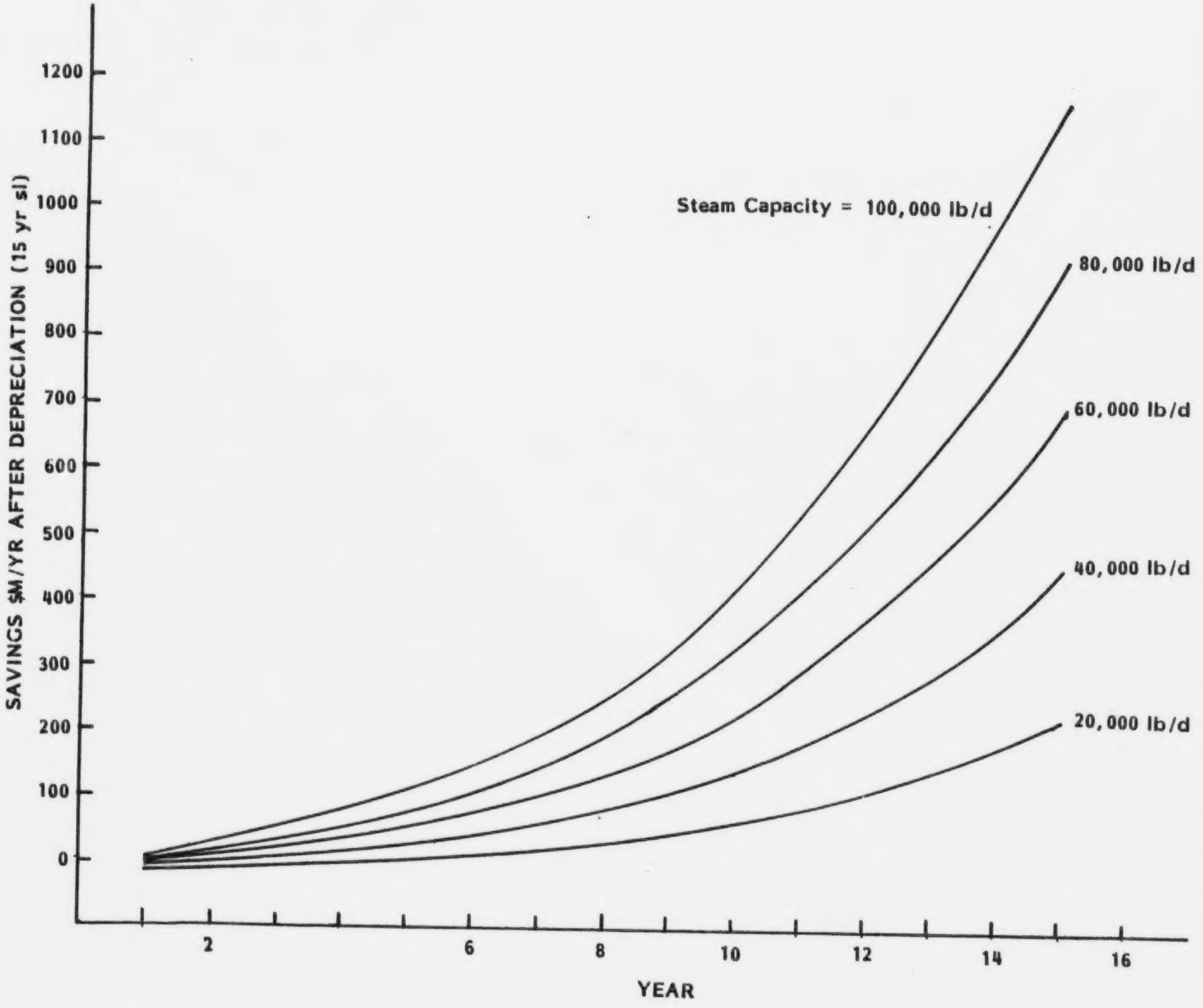


Figure 9. Annual Savings vs. Year

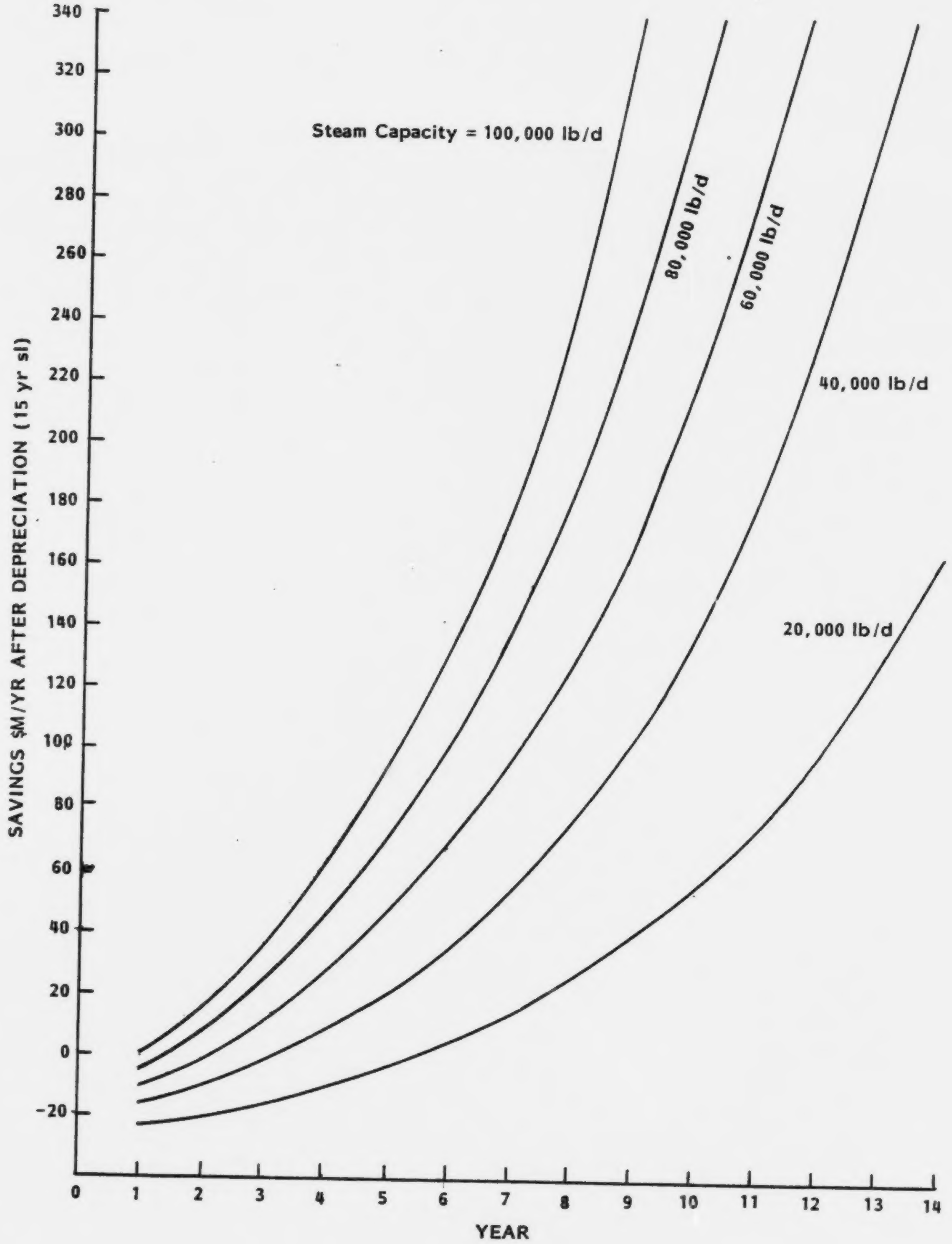


Figure 10. Annual Savings vs. Year (Detail)

TABLE 20. VALUES USED IN COMPUTATIONS FOR GENERATION OF CURVES IN FIGURES 7 THROUGH 10

Item	Units	Year 1 Base Cost	Escalation %/Yr
Gas	$/MM Btu	3.25	20
Electric	$/kWh	0.0104	10
Coal	$/MM Btu	2.05	5

$\frac{\text{THERMAL}}{\text{ELECTRIC}}$ = 3.79 (Average for plants <90,000 lb Anode consumed annually)

TABLE 21. INSTALLED CAPITAL COSTS FOR VARIOUS COGENERATION CAPACITIES PERTAINING TO FIGURES 7 THROUGH 10

Plant Steam Capacity Mlb/Day	Total Installed Capital Cost
20	472,255
40	503,259
60	534,264
80	565,269
100	596,273

to 21.5 percent for the small plants and 15.2 percent for the large plants. The adjusted values are then:

Plant Size	Average Annual Thermal Consumption 10^{10} Btu
Small	1.73
Large	8.21

Secondly, both the electrical and thermal consumption values must be adjusted to reflect the fact that although most platers operate only one shift per day, 5 days/week, averaging 2,000 hours/year, the plants have some energy consuming devices on during the two off-shifts and on weekends. In order to properly size the cogeneration facility, the peak operational requirements must be estimated. For the purpose of this analysis, a value of 2/3 the average annual consumption will be used to represent the energy consumed annually on a 2,000 hour/year basis. Thus the adjusted values as used in the cogeneration analysis are presented in Table 22.

Values for electrical, gas, and coal costs used in the analysis are presented in Table 23.

In calculations associated with generating the curves in Figure 7 through 10, different escalation rates were applied for each energy source to reflect recent deregulation of gas prices and energy source availability.

In addition, the thermal/electric ratio used in sizing the cogeneration facilities presented in the figures was selected as the average for plants consuming $\leq$90,000 lb of anode annually. This value was chosen since the majority of plating shops located in the Cleveland area are relatively small compared to those presented in the Atlanta, Georgia study. The values used may be reviewed in Table 22.

For the calculation of annual savings in all situations considered, the installed capital investment was annualized over a 15-year period and subtracted from the gross savings prior to apportioning the remaining savings.

TABLE 22. ADJUSTED VALUES USED FOR COMPUTATIONS IN CASE STUDIES

Description	# Anode Consumed Annually	Adjusted Annual Electrical Consumption, 10^{10} Btu	Adjusted Annual Thermal Consumption 10^{10} Btu	Thermal Electrical Use Ratio
Small Plant	$\leq$90,000	0.303	1.15	3.79
Large Plant	>90,000	0.993	5.47	5.51

Calculation of Adjusted Consumption

Electricity:

Small plant average annual electrical consumtion = 0.454×10^{10} Btu

Large plant average annual electrical consumption = 1.49×10^{10} Btu

Adjusted annual consumption = 2/3 x average annual consumption

for small plants: $2/3 \times 0.454 \times 10^{10}$ Btu = 0.303×10^{10} Btu

for large plants: $2/3 \times 1.49 \times 10^{10}$ Btu = 0.993×10^{10} Btu

Thermal Energy:

Small plant average annual thermal consumption = 1.73×10^{10} Btu

Large plant average annual thermal consumption = 8.21×10^{10} Btu

Adjusted annual consumption = 2/3 x average annual consumption

for small plants: $2/3 \times 1.73 \times 10^{10}$ Btu = 1.15×10^{10} Btu

for large plants: $2/3 \times 8.21 \times 10^{10}$ Btu = 5.47×10^{10} Btu

Thermal-Electrical Ratio:

For small plants: 1.15×10^{10} Btu/0.303×10^{10} Btu = 3.79

For large plants: 5.47×10^{10} Btu/0.993×10^{10} Btu = 5.51

TABLE 23. UNIT COSTS FOR CASE STUDIES

Item	Unit	Unit Cost, $
Gas	MM Btu	3.25
Purchased Electricity	kWh	0.0104
Coal, Delivered	MMBtu	2.05
Cogenerated Electricity	kWh	0.008

Calculation of Unit Costs

Gas: Rates (East Ohio Gas Co.)
$3.41/MCF 1st 100 MCF
$3.33/MCF next 4,900 MCF
$3.146/MCF next 20,000 MCF
$3,034/MCF over 25,000 MCF

Overall Average Thermal Consumption = 5.95×10^{10} Btu

Assuming all thermal energy is produced by gas boilers, annual consumption is

$(5.95 \times 10^{10}$ Btu/yr)(MCF/1,024,000 Btu) = 58,105 MCF/yr
or 4,842/mo

Thus, the monthly bill would be $16,132 averaging $3.33/MCF - $3.25/MM Btu.

Electricity: Rates (Cleveland Municipal Light & Power Co.)
$0.016/kWh less than 40,000 kWh
$0.11/kWh less than 40,000-60,000 kWh
$0.0085/kWh less than 60,000-400,000 kWh
$0.0060/kWh more than 400,000 kWh

Overall Average Electrical Consumption = 9.72×10^{10} Btu

$(9.72 \times 10^{10}$Btu/yr)(kWh/3,412 Btu)(1 yr/12 mo.) = 237,397 kWh/mo

Thus the monthly bill would be $2,468, averaging $0.0104/kWh

Coal: Rate (Consolidation Coal Co.)
$41/ton delivered

($41/ton)(1 ton/$2 \times 10^7$ Btu) = $2.05/MMBtu

REFERENCES

1. "Environmental Pollution Control Alternatives: Centralized Waste Treatment Alternatives for the Electroplating Industry," EPA 625/5-81-017, June 1981.

2. Cushnie, G. C., D. Harrison, et al, "Cleveland Resource Recovery Park - Preliminary Engineering Design," final report on Work Effort 12, Contract 68-03-2907, January 1982.

3. SBA Rules and Regulations, Part 121, "Small Business Size Standards," October 5, 1978.

PART III. AN INVESTIGATION OF A SPECIFIC SITE FOR THE CLEVELAND RESOURCE RECOVERY PARK

SECTION 1

INTRODUCTION

CLEVELAND INDUSTRY

A close examination of the structure of American industry reveals that the manufacturing capability of the United States is based upon two foundations:

- The major manufacturing and distributing corporations
- The smaller manufacturers which provide the specialized components and services needed by the larger manufacturers

The flexibility, drive and hands-on involvement of the owner/managers of these small firms have always provided a complementary balance to the large corporations--which have the capital, marketing, and distribution resources to participate in national and international markets.

Nowhere is the free market in greater evidence than when the smaller manufacturers are competing for contracts to provide parts for the product of a major corporation. The aggregate employment of these smaller manufacturers usually equals and often exceeds that of the major corporations.

There are few, if any, cities in the United States where this symbiotic relationship is better illustrated than in Cleveland, Ohio. Cleveland currently has manufacturing facilities owned by the top 500 U.S. corporations, and facilities owned by independent operators. The independent facilities consist of:

- Job Shop Electroplaters
- Mechanical Fabricators
- Specialty Formulators
- Printed Circuit Board Manufacturers

- Surface Finishers

- Specialized Repair and Maintenance Firms

The combination of resources, transportation, labor and proximity to markets which brought the major industries to Cleveland in the past also brought a flourishing array of small manufacturers to provide the services and products needed by the larger corporations.

All of the current problems of the larger corporations such as aging equipment and lack of capital for modernization have been even more intensely felt by the smaller manufacturers. It has reached the point where most do not have the capital, or credit, to introduce known technology for improving efficiency. This has finally reached a crisis for those unable to afford the equipment necessary to control the toxic wastes generated by their facilities.

Most of Cleveland's manufacturers are faced with the same list of requirements:

- Modernization of aging production lines with equipment which will improve productivity and lower manufacturing costs

- Reduction of energy costs

- Control of pollution to acceptable levels

- Improvement of working conditions

Credit availability, high interest rates, and current depressed economic conditions prevent the small manufacturers from raising the capital to meet these goals. The favorable conditions which initially placed the city of Cleveland in a leading position in the American industrial community can be restored. This is true of most northern cities whose industrial facilities are having economic problems. Given a revitalizing influx of capital improvements, these cities can regain their world leadership.

Over the long run, the rebuilding of Cleveland's industrial facilities is a wise investment. The underlying question, however, relates to finding the most practical and cost-effective method of proceeding. Under current conditions there is insufficient capital available for a plant-by-plant modernization.

The answer appears to lie in a concept initially developed to reduce the costs of complying with pollution control requirements for small manufacturers. Numerous studies[1] have shown that, for most industrial cities, major savings in total pollution control costs could be obtained if a centralized facility is established to treat the concentrated wastes of a number of manufacturers. This concept has been in practice in the Ruhr Valley of Germany for over ten years, with almost complete success. The facilities have been funded both privately and by municipalities (using their credit and capital). In all cases they are fully suported by fees charged to those sending wastes to the facility. The cost of using the central facilities is less than on-site treatment, which represents a major savings to the participating industries.

The centralized concept for waste treatment only offers a solution to manufacturers' waste treatment problems. The problems of replacing outdated equipment, obtaining cheaper energy, and incorporating cost saving automation remain. The resolution of these additional problems for small manufacturers is incorporated into the concept of the Cleveland Resource Recovery Park.

The Cleveland Resource Recovery Park would not only provide waste treatment for all occupants, and those within a practical shipping range, but would offer the following additional features:

- Facilities for recovering components of wastes
- Sites for relocating and modernizing facilities
- Lower cost steam and electricity through a central boiler-cogeneration facility
- Centralized laboratory facilities
- Centralized use of computers
- Credit for qualifying participants
- Centralized shipping services

The initial focus of the RRP concept as described herein has been on the electroplating industry, an industry in need of the cost savings and opportunities for renewal of facilities which the Cleveland Resource Recovery Park can provide. While the projections contained in this report envision the participation of the electroplating industry alone, they are indicative of the potential benefits of reindustrialization when applied to the full scope of industrial activity to which the concept is applicable.

THE RESOURCE RECOVERY PARK

The electroplating industry is the first of 34 industries in the country to have to comply with pretreatment regulations and, as such, has an opportunity to set a precedent. Cleveland, along with many other cities, has a concentration of metal plating shops whose wastes contribute to measurable levels of heavy metal residues in sewage plant sludges.

The Cleveland area has more than 100 plating shops, employing more than 2,500 persons. Their services are used by a number of other industries, which need the plated services for their own products--automobiles, for instance.

An unusually large number of electroplating businesses are family-owned shops that cannot afford to buy the equipment needed to comply with federal regulations. It is estimated that more than 20 percent of the shops could be forced out of business.

At stake in Cleveland are approximately 2,500 jobs, employing a substantial number of city of Cleveland residents. Cleveland's electroplaters, who apply metal finishes to fabricated metal products, provide a crucial service to other local firms and draw business from a region that reaches into Michigan and Pennsylvania. Any reduction in the size and capability of the plating industry could have a severe ripple effect on the Cleveland economy and the region served.

In 1979 and 1980, Cleveland was one of five metropolitan areas chosen as the subject of a case study under federal contract[1] to determine the feasibility of building central treatment facilities for the electroplating industry. Cleveland was the subject of further study in 1981 that closely examined the economics of building a central treatment facility around which a number of plating companies could gather, and which many more could utilize.

A key facet of the study[2] was examination of the resource recovery concept--recycling and reclamation of the valuable metals used in the electroplating process. The concept has appealed to local industry and government and environmental groups as a means of economically solving a major environmental problem. This strong interest has permitted EPA to continue its research effort by funding a project to investigate technical and economic details for a specific RRP potential site.

As discussed in the previous project report,[2] there are a number of important criteria that must be considered in siting the RRP. Figure 1 illustrates several concerns of siting that are most applicable to highly industrialized areas. The example

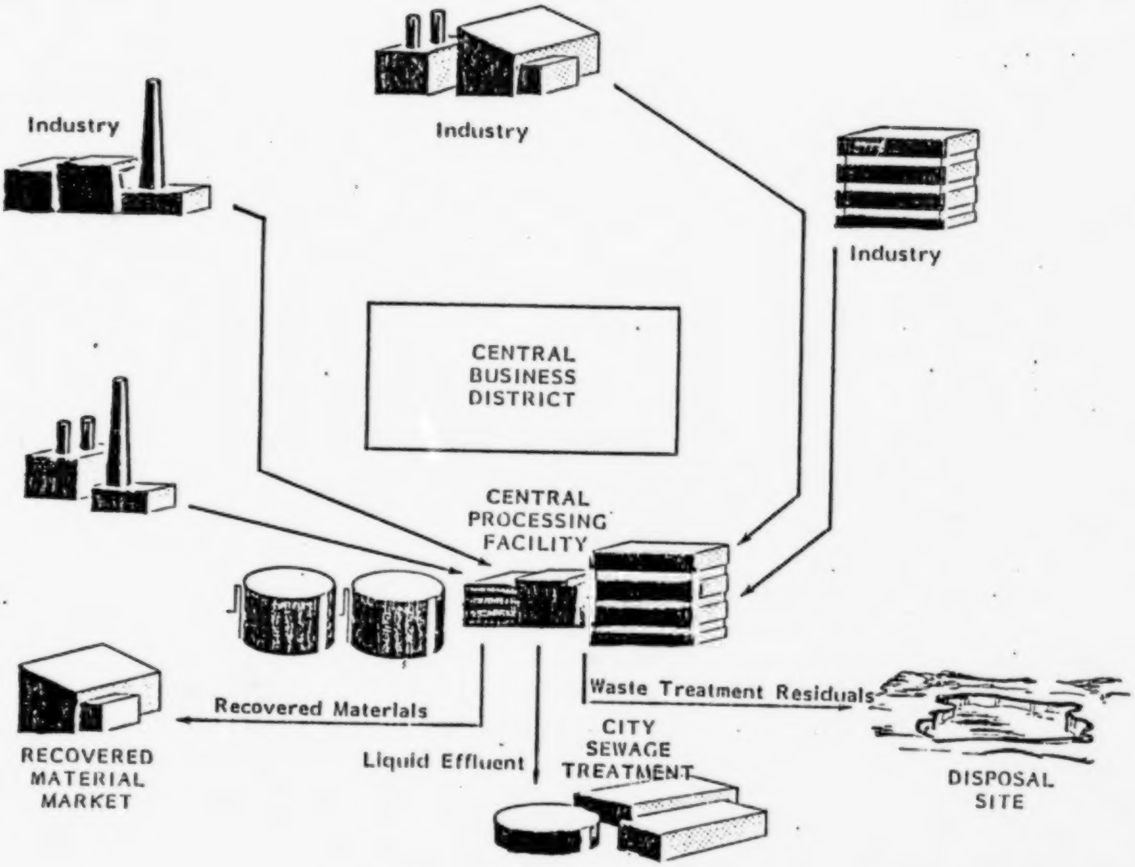

Industry
Industry
Industry
CENTRAL BUSINESS DISTRICT
CENTRAL PROCESSING FACILITY
Recovered Materials
RECOVERED MATERIAL MARKET
Liquid Effluent
CITY SEWAGE TREATMENT
Waste Treatment Residuals
DISPOSAL SITE

Figure 27. Central Treatment System Overview

represents an industrialized metropolitan area typical of those found in the midwest and northeast. The industrialized sectors of the city are located outside the central business district. The central processing facility is also located outside the central business district and away from residential areas. However, the facility must be located close enough to industry to allow economical waste hauling. Also, the central facility must be sited close to major transportation routes that allow truck transport. Waste hauling through the business district and residential areas should be minimized.

The site for ultimate disposal (not specifically considered under the scope of this project) of unrecoverable residuals will be at an acceptable disposal facility not located at the central processing facility. Although it would be convenient to locate the disposal site next to the central processing facility from a siting standpoint, this would be impossible in most metropolitan areas. The major obstacle in disposal siting is the public's refusal to allow industrial waste to be permanently discarded near residential and business sectors. Also, the disposal area may require a large tract of land which would be very expensive within the metropolitan area. Therefore, the disposal site, in most instances, must be located at least 10 miles outside the metropolitan area.

During operation, industrial wastes would be collected from participants either on an as-needed basis or according to a set schedule. The waste would be transported by trucks using major highways and usually circumventing residential and business areas. The waste would be delivered to the central facility and processed. Any recovered materials would be shipped to appropriate markets, residual solids (usually sludge) would be sent to the disposal site. The treated liquid effluent from the central processing would be discharged to the city sewer system.

Individual waste generators are expected to participate in the RRP system by first concentrating their wastes as much as possible before transport to the central facility. For electroplaters this can be achieved by either utilizing innovative rinsing techniques (e.g., series rinsing, still rinsing) or through application of a technology such as ion exchange. In the latter case, ion exchange equipment could be leased and serviced by the central facility management. Instead of sending concentrated rinsewaters, the ion-exchange cylinders would be transported to the central facility where they would be regenerated for treatment or recovery.

The initial design of the Resource Recovery Park has been based on the latter concept described above whereby all dumps requiring treatment from all of the Cleveland electroplaters are shipped to the Resource Recovery Park for disposal. In addition, all running rinses requiring treatment are serviced by in-plant ion exchange modules leased to the plater by the Resource Recovery Park. When these modules require regeneration, they are trucked back to the Resource Recovery Park, where regeneration followed by treatment of the regenerant and disposal of residuals takes place. The potential for recovery of useful metal values is enhanced by the use of ion exchange, since the regenerant under certain conditions can be returned to plating shops.

WOODLAND EAST COMMUNITY ORGANIZATION (WECO) SITE

Efforts completed under previous projects have been expanded under this project with the analysis of a specific site as a potential Cleveland Resource Recovery Park. The site selected for this design effort is the Woodland East Community Organization (WECO) site in Northeast Cleveland. WECO is a nonprofit group comprised of businesses from the Woodland East area that support commercial and industrial growth in their area. The WECO site was selected for analysis by Task Force representatives based on CENTEC Corporation recommendation. It is not necessarily the best possible site but was considered as a potential site because of its location, size and the fact that a large electroplating company is located on an adjoining property. A preliminary plan for the WECO site involves direct piping of rinsewater from the adjoining electroplating company to the WECO treatment facility.

The Resource Recovery Park was sized in the project[2] both on the assumption that all 76 platers included in the analysis would decide to take part, and for a reduced capacity with 30 participants. The second design has been used as the basis for the analyses presented herein because it has been selected as the design basis by investors. Additionally, the previous marketing study[3] performed for the RRP shows that the required capacity, based on expected participation, approaches the "30-plant" design.

Subsequent sections of this report present a description of a proposed RRP site, the management and organizational plan, the marketing analysis, the financing strategy, and the expected operating results.

CONCLUSIONS

The proposed Woodland East Community Organization (WECO) site is a viable Resource Recovery Park (RRP) site from a technical and economic standpoint. A major technical asset of the site is its location relative to the Cleveland plating industry. As discussed in Section 4, the site under consideration is within 2 miles of most of Cleveland's plating shops. Another technical asset is the size of the site (5 acres) and the availability of additional space within the Woodland East area for relocating platers which may allow for direct piping of wastes. Relocation to the Woodland East area is encouraged by WECO. Truck access was identified as a potential problem with the proposed site since transport vehicles would need to travel through residential areas. A planned change to the roadway, however, may alleviate this problem.

The WECO site appears to be a viable financial investment; however, the discounted cash flow (DCF) rate of return (26.1 percent) is substantially less than that projected previously for a Cleveland RRP[3], due primarily to the fact that costs for treatment equipment and existing buildings at WECO significantly exceed the earlier estimates. The average percent return on investment was calculated to be 13.3 percent and the payback period was 10.1 years.

The results of the marketing study indicate that 54 of the 76 Cleveland area plating shops could economically benefit by using the WECO system. This projected market is only two shops less than the market estimate calculated under the previous Cleveland RRP project.[3]

As planned, the WECO RRP would utilize the ion exchange module concept analyzed under the previous project. In addition, a continuous waste stream would be pumped to the treatment facility from a nearby large plating shop. The continuous flow presents a solid income base and would therefore contribute to the success of the system. Since additional space is available for relocating platers around the proposed site, there exists the potential for increasing the expected volume of continuous flow.

The centralized treatment system designed for the WECO site incorporates conventional destruct technologies (i.e., cyanide oxidation with Cl_2, chromium reduction with SO_2, and metal hydroxide precipitation) and a technology for chromium recovery. The facility is designed to treat concentrated wastes, dilute rinse water and ion exchange regenerate. The total capital investment required to construct the facility is $3,343,200. The annual operating costs were estimated to be $482,671.

Private ownership has been selected as the ownership option. This will preclude any local government or industry participation in control of the facility, selection of clients, or determination of fees. However, it will have the advantage of freeing the individual industries from liability and minimizing the economic impact on the individual industries by reducing their capital outlay.

The recommended method for raising the equity portion of the capital required by a private corporation is a private placement of stock. When a private placement of stock is made, no Security Exchange Commission (SEC) registration is required, thus avoiding both the associated high legal and underwriting costs and the long waiting period for approval. Using this method, participation is limited to 35 nonaccredited investors; however, an unlimited number of accredited investors may participate.

Debt financing alternatives have become limited due to changes to tax laws, fluctuating interest rates, and other economic factors. However, the State of Ohio does provide financing for projects such as the RRP under their Economic Development Financing Act (Senate Bill 313). This method of debt financing has been recommended by the Cleveland Area Growth Association. Financing of up to 75 percent of project cost can be obtained with Senate Bill 313 at an interest rate 2 percentage points below the average rate of interest charged for all other direct loans during that year.

In addition to the projected economic waste treatment benefits, the potential exists for installing a cogeneration facility and reducing energy costs for companies located within the WECO Park. The cogeneration facility would provide both electrical and thermal energy requirements.

The use of coal- and natural gas-fired steam turbine/generator systems were considered in the cogeneration analysis. In both cases, it was determined that potential savings exist. The use of the coal-fired system would be 2.6 times more profitable than the gas-fired system. The annual savings after depreciation for the coal-fired system were estimated to be $1,166,000.

SECTION 3

RECOMMENDATIONS

INVESTIGATE ADDITIONAL SITES

The site investigated during this project is considered as a viable site for a Cleveland Resource Recovery Park. However, additional sites should be investigated and compared using a similar analysis to that presented in this report. Searches for new sites in Cleveland should consider finding a less expensive site (land and buildings) which has good access for waste hauling trucks.

DEMONSTRATE THE ION EXCHANGE MODULE CONCEPT

Ion exchange is a well proven technology for removing metals and cyanide from waste streams; however, the concept of using modules and regenerating at a central facility is relatively new. Without solid proof that the concept works, electroplaters may be reluctant to participate in the RRP system. It is therefore recommended that a demonstration project be undertaken to provide the required data and visual proof. The demonstration should be performed in a Cleveland plating shop which is not currently meeting 1984 pretreatment standards.

CONTINUE INVESTIGATION OF RECOVERY ALTERNATIVES

As discussed in the Cleveland RRP report,[2] the recovery processes considered for the Cleveland RRP are not yet commercially available. Therefore, before they can be incorporated into the RRP, additional engineering efforts are required.

It is recommended that continued efforts focus on recovery systems for the waste streams which are projected to provide the highest return on investment. The primary candidate is chromium waste. Other waste streams that should be considered are zinc and cadmium. The new efforts should include a refinement of the recovery process design and the use of pilot studies.

Uncertainties associated with the proposed chromium process are as follows:

- Durability of anion resin for collection and concentration of chromate ions. Chromate ions are strong oxidizing compounds which have the potential to gradually degrade the physical structure of the resin beds. Highly cross-linked resins should exhibit the longest service life. Resin manufacturers can provide information on type of resin to use and expected service life.

- Efficiency of ion exchange regeneration using catholyte solution. The resin's selectivity for chromate ions compared to other anions in the catholyte solution will determine the efficiency of the resin regeneration and the concentration profile of chromate in the catholyte solution. Higher catholyte solution chromate concentrations will yield higher capacity per unit size in the diaphragm cell. This concern is not critical for the feasibility of the proposed process, but will affect the chemical and equipment costs.

- Design of the diaphragm cell. A similar component is used in a process recovery system to separate chromate ions from rinse water after chromate process baths (ChromeNapper™). The size of the unit, however, is considerably smaller than what is required for this application. A diaphragm cell is used for chromic acid purification in a similar application at the Chuo Industrial Co-operative in Japan. The success of a diaphragm cell for this type of application has been demonstrated; if commercial units with the required capacity are not mass produced, a more expensive, special order system may be required.

SECTION 4

SITE DESCRIPTION

GENERAL

The proposed site for the Resource Recovery Park (RRP) is located on property currently owned by the Empire Plating Company. The site borders Holton Avenue and East 90th Street. The Empire Plating property is part of an area known as the WECO (Woodland East Community Organization) area. WECO is a nonprofit organization which was founded in 1971 by industrial and commercial firms to increase the economic potential and general living conditions of their urban environment. The organization itself has not shown interest in investing in the RRP; however, they support the concept and favor locating the facility within the Woodland East community. The WECO area has unofficial boundaries of Woodland Avenue and Buckeye Road on the north, East 93rd Street and Woodland Road on the east, Kinsman Road on the south, and East 75th Street on the West. This area contains approximately 500 acres, as shown in Figure 2.

EXISTING BUILDINGS AND EQUIPMENT

The proposed RRP site includes five acres, on which there are located four buildings. As planned, each of the buildings will be utilized for the RRP operation after suitable renovation. The proposed plan for using the existing buildings is described in Figure 3. The office and laboratory building was last used as an office and will require little renovation. That building has a floor area of 6,700 square feet. The waste processing building which is 11,000 square feet will require significant renovation. The metal reclamation and drum storage buildings are 5,000 square feet and 22,000 square feet, respectively. Minor renovation is required for these buildings.

Figure 2 presents an overview of the RRP site and surrounding buildings, all of which are currently owned by the proprietor of Empire Plating. Empire Plating presently has a waste treatment system which is located on the west side of the plating facility.

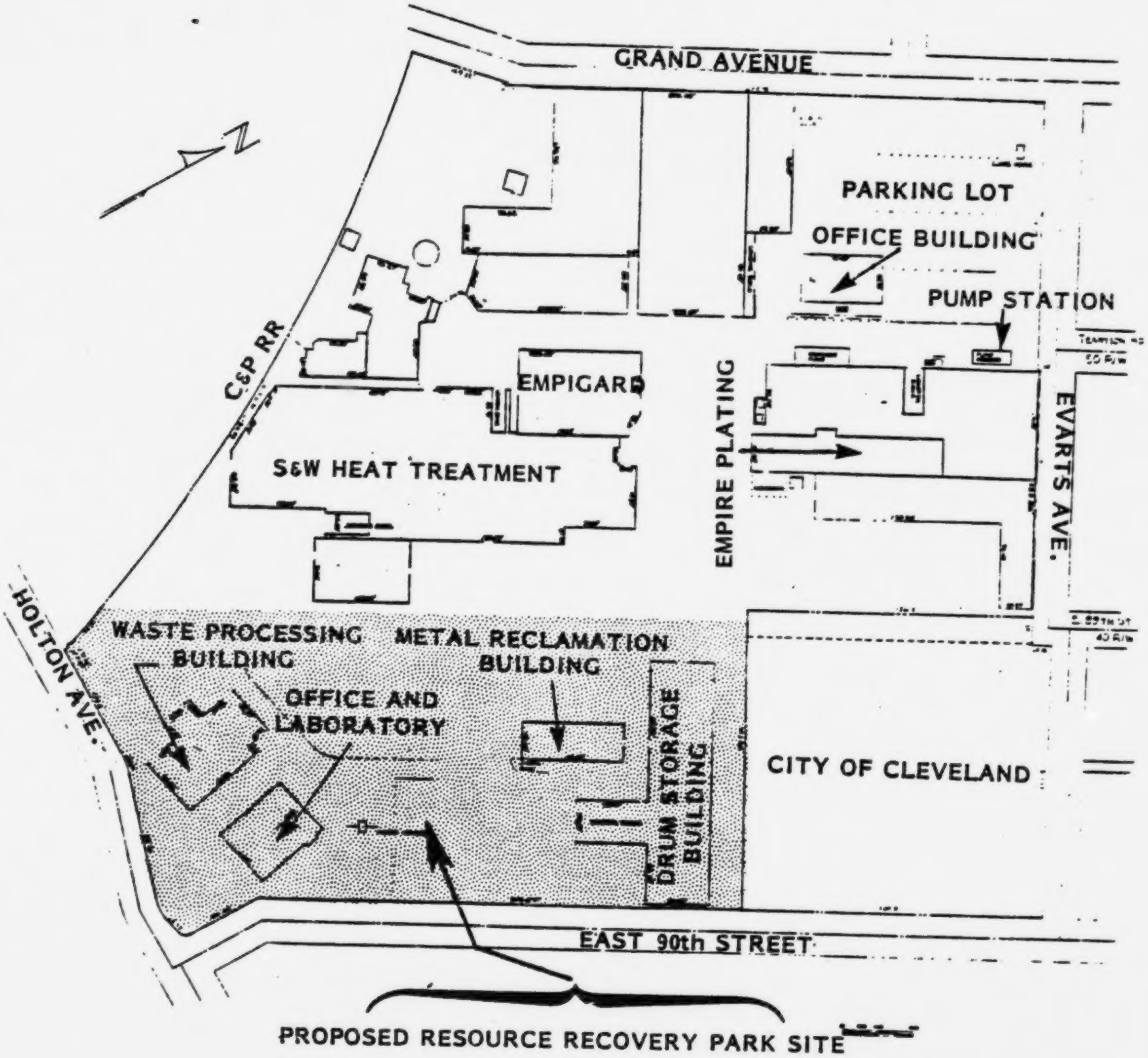

N
GRAND AVENUE
PARKING LOT
OFFICE BUILDING
PUMP STATION
Tennyson Rd
50 R/W
C&P RR
EMPIGARD
S&W HEAT TREATMENT
EMPIRE PLATING
EVARTS AVE.
E. 89th St
40 R/W
HOLTON AVE.
WASTE PROCESSING BUILDING
METAL RECLAMATION BUILDING
OFFICE AND LABORATORY
DRUM STORAGE BUILDING
CITY OF CLEVELAND
EAST 90th STREET
PROPOSED RESOURCE RECOVERY PARK SITE

Figure 2. General Site Plan

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)

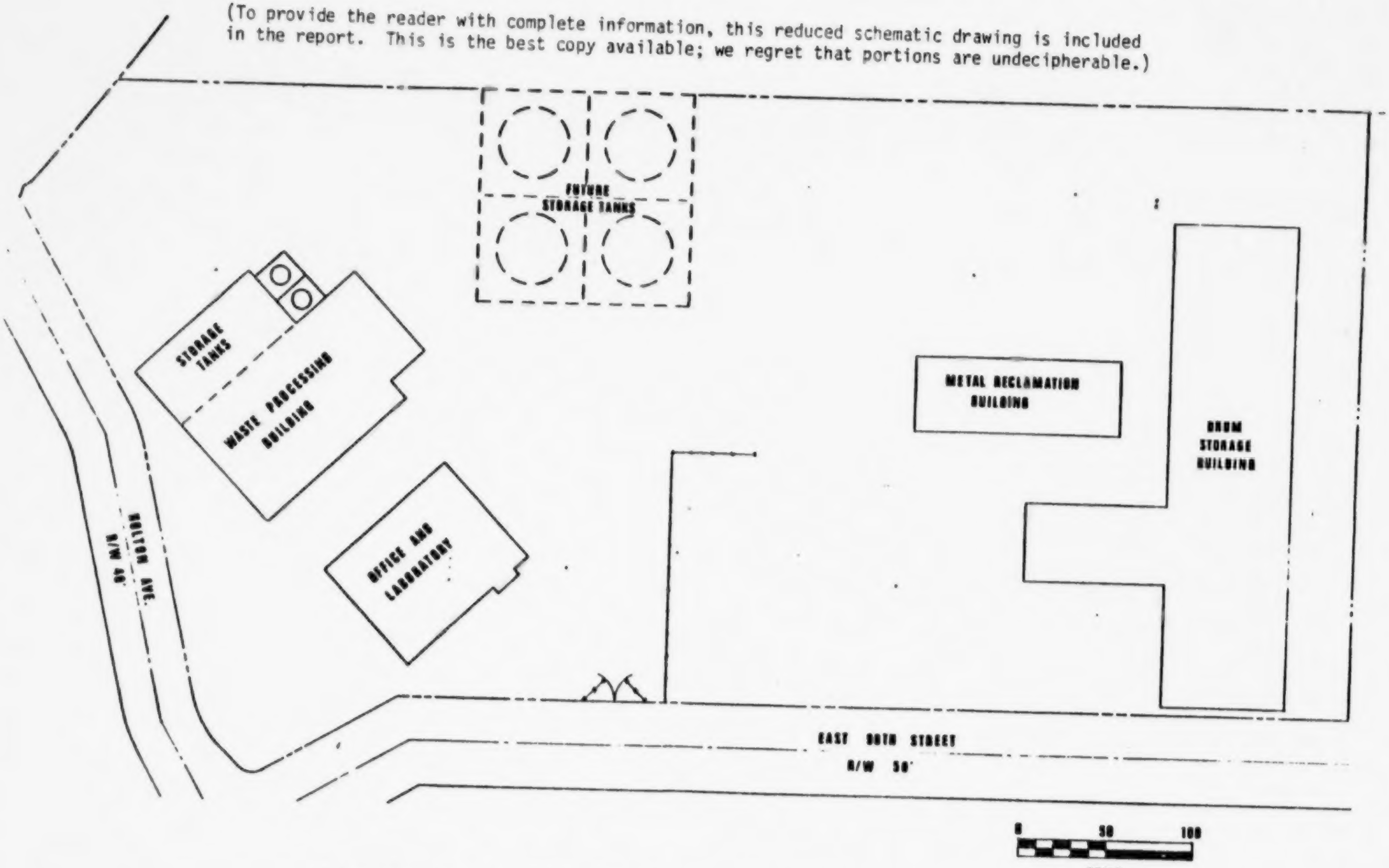

FUTURE STORAGE TANKS
STORAGE TANKS
WASTE PROCESSING BUILDING
OFFICE AND LABORATORY
METAL RECLAMATION BUILDING
DRUM STORAGE BUILDING
BOLTON AVE.
R/W 40'
EAST 80TH STREET
R/W 50'
0
50
100
SCALE

Figure 3. Resource Recovery Park Site Plan

Note: All buildings currently exist. The storage tanks are planned.

The equipment at Empire will be sold to the RRP and moved to the waste processing building (Figure 3). Wastewater from Empire will then be pumped to the waste processing facility and treated with wastes from other shops.

The existing equipment at Empire which will be sold to the RRP includes the following:

- 1 - Lamella settler (60 gpm)
- 2 - 6,000 gal FRP mixing tanks (10' dia X 10' ht) w/mechanical mixer and cover
- 1 - 5,000 gal FRP mixing tank (9' X 10' ht) w/mechanical mixer and cover
- 1 - 2,000 gal FRP mixing tank (6' dia X 10' ht) w/mechanical mixer and cover
- 3 - 600 gal FRP mixing tanks (5' dia X 4'-2" ht) w/mechanical mixer and cover
- 1 - 5,000 gal FRP storage tank (10' dia X 11' ht)
- 6 - chemical feed pumps
- Instrumentation
- Spare Part Inventory
- Piping

SITE SUITABILITY

Truck access to the RRP will be from East 90th Street. The majority of trucks will enter the WECO area from Route 77. Initially this will require routing truck traffic east onto Woodland Avenue to Buckeye Road then to E. 90th Street. Heavy use of this route by trucks may present some problems since several of the roads include residential areas. A future extension to Holton Avenue is planned by the city (but not in the immediate future) which will include an exit at 55th Street over Kinsman Road and an almost direct connection to the RRP (Figure 4). If built, the future roadway will greatly enhance access to the RRP.

The WECO site has a major advantage in terms of its relative location to the Cleveland plating industry. As indicated

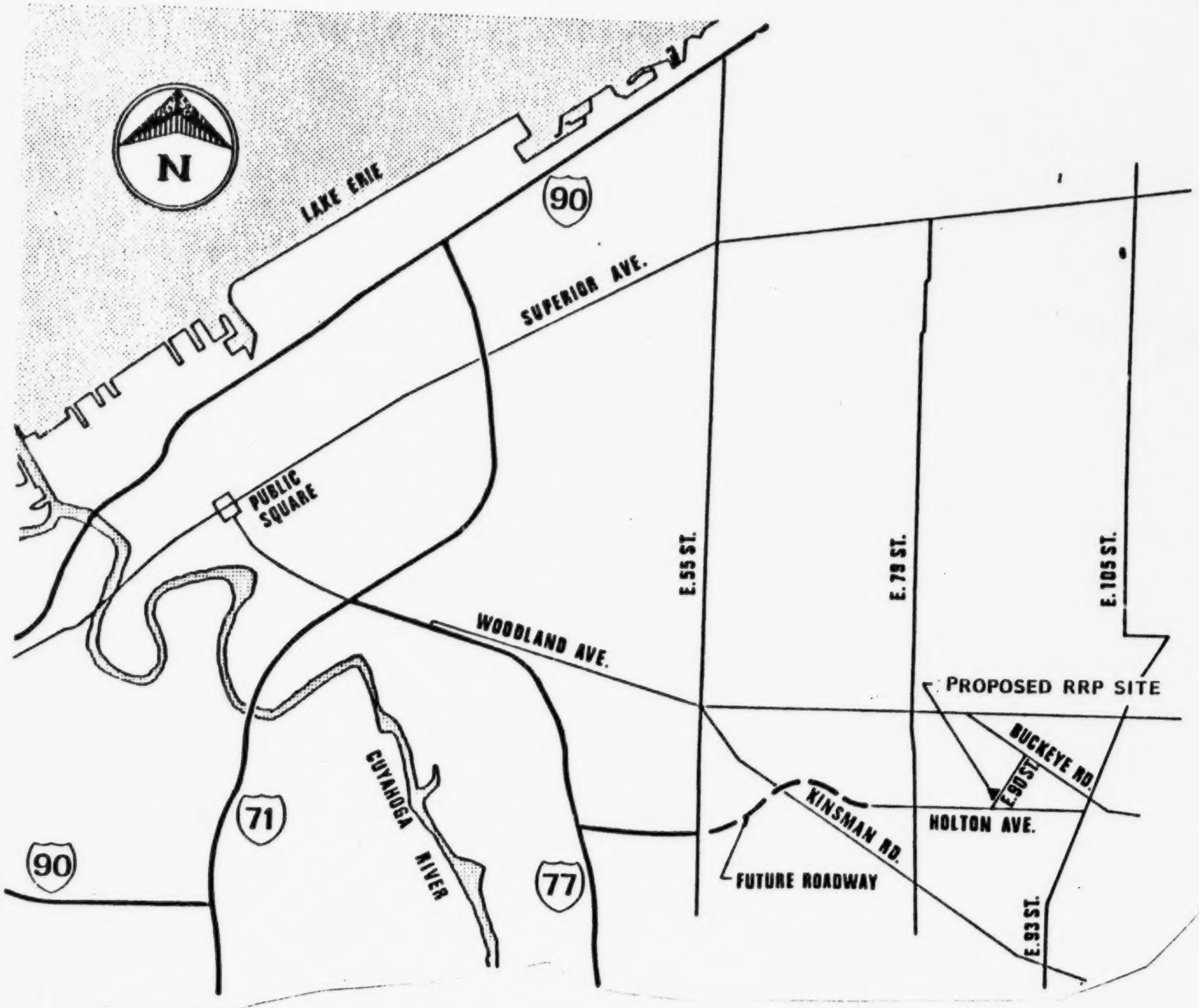

N
LAKE ERIE
90
SUPERIOR AVE.
PUBLIC SQUARE
WOODLAND AVE.
CUYAHOGA RIVER
71
90
77
E. 55 ST.
E. 79 ST.
E. 105 ST.
PROPOSED RRP SITE
BUCKEYE RD.
E. 90 ST.
HOLTON AVE.
KINSMAN RD.
FUTURE ROADWAY
E. 93 ST.

Figure 4. Resource Recovery Park Location Map

in Figure 5, the majority of platers in Cleveland are located within 2 miles.

The Woodland East Community Organization and the Woodland East area itself offer additional advantages to the proposed site. The initial WECO organizers included 18 major industrial employers, several retail commercial estabishments, churches and a residential complex. Major concerns of the founding members were the area's crime rate, deteriorating environment, and diminishing employment opportunities. To attack these problems, WECO initiated two projects: the formation of a localized crime prevention force and the creation of a modern industrial park. To aid in the latter effort a commitment was obtained in 1972 from the Economic Development Administration for a planning grant of approximately $94,000.

The efforts by WECO have had positive effects. The group has been able to stem the rush of companies to the suburbs and rebuild the WECO area into a productive urban park. WECO members see the RRP as a significant contributor to their area and a continuation of their economic progress. The RRP can offer a savings to metal finishing companies presently located within the WECO area and can attract new companies to relocate into the WECO area.

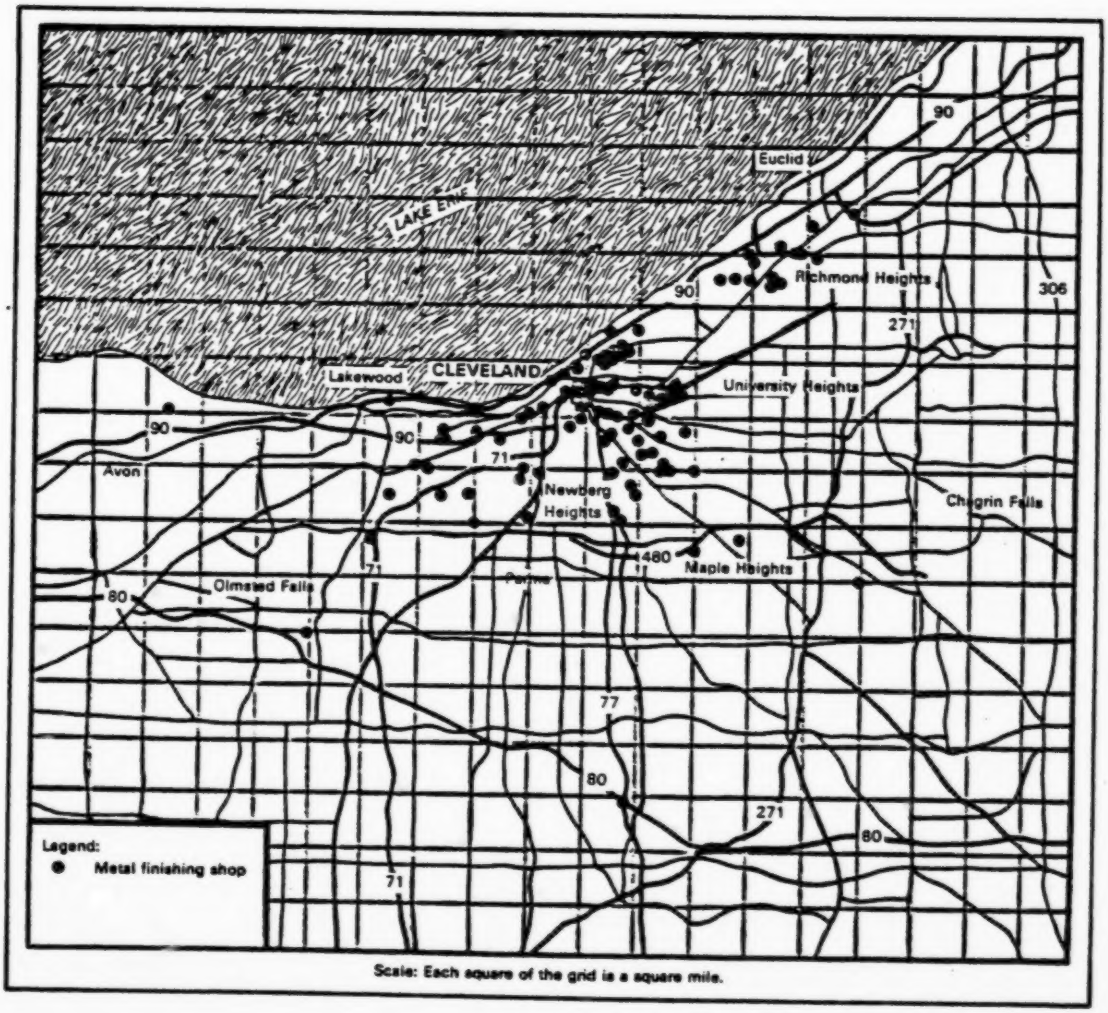

LAKE ERIE
Euclid
90
Richmond Heights
306
271
University Heights
CLEVELAND
Lakewood
Avon
71
Newburg Heights
Chagrin Falls
480
Maple Heights
Parma
Olmsted Falls
80
77
Legend:
● Metal finishing shop
Scale: Each square of the grid is a square mile.

Figure 5. Location of Metal Finishing Shops in the Cleveland Area and Potential RRP Site (see arrow).

SECTION 5

OWNERSHIP, OPERATIONS AND MANAGEMENT PLAN

Various potential ownership, operational and management plans have been examined during previous centralized waste treatment projects.[1,2,3] These management and ownership options fall into three basic categories: private, public, or cooperative ownership. Private ownership would be by firms that specialize in waste treatment and disposal, or by an electroplater that builds a central facility to handle his and other platers' waste. Public ownership could be by state, county or municipal government or by a quasigovernmental economic development corporation. Finally, cooperative ownership implies either a joint venture or a general-limited partnership of central treatment facility (CTF) users.

In addition to full private and full governmental electroplater cooperative ownership, there are two scenarios that represent variants to the basic management options. These include 1) government or electroplater ownership of the land with an outside firm owning and operating the CTF and 2) government or industry ownership of the land, buildings, and equipment used in the CTF with an outside firm being hired to manage the facility.

In Table 1, these three options are distributed into six management scenarios. While these scenarios are not the universe of all possible choices, they are presented as a good representative cross-section.

Although final plans have not yet been developed for the Cleveland Resource Recovery Park (RRP), interested private partners have indicated that an RRP project will be undertaken. The expected type of ownership is private ownership with complete managerial control, operational liability, and financial responsibility resting with a single firm.

Implementing the private ownership option will preclude any local government or industry user participation in control of the facility, selection of clients, or determination of fees. This option does, however, have the advantage of freeing the individual industries from liability and minimizing the economic impact on the individual industries reducing their need for capital outlays. In addition, the establishment of a privately

TABLE 1. POSSIBLE MANAGEMENT OWNERSHIP OPTIONS

COMPLETE PRIVATE OWNERSHIP	1. Complete ownership, financing, and management responsibility by an outside firm.
↑	2. Complete ownership and management responsibility by an outside firm with financing assistance (i.e., loan guarantees, loans, or nonrecourse financial investments) by state/local government and/or an industry user group.
│	3. Ownership, financing, and management responsibility by an outside firm of a CTF built on government-owned or industry-owned land.
│	4. Ownership and management responsibility by an outside firm of a CTF built on government-owned or industry-owned land with state/local government and/or industry financing assistance.
↓	5. State/local government and/or industry user group ownership and financing of a CTF that is managed under contract by an outside firm.
GOVERNMENT AND/OR USER GROUP OWNERSHIP	6. Complete state/local government and/or industry user group ownership, financing, and management responsibility.

owned centralized treatment facility and RRP will expand the state and municipal tax base.

The current management plan favored by the potential WECO site investors includes a contractual arrangement with a firm to operate the treatment facility. The selected firm currently operates and maintains four waste treatment facilities in the Cleveland area. It is expected that the firm will lease the RRP treatment facilities from the owners and be responsible for marketing and sales, operation and maintenance, permit acquisition and other related functions.

SECTION 6

PROCESS DESIGN AND COSTS

SYSTEM DESIGN

The waste treatment/recovery system designed for the WECO site is a highly flexible system which includes both batch and continuous treatment. The major waste streams that will be received at the facility include:

- Ion exchange modules
- Spent process solutions (concentrated wastes)
- Sludge (at 2 percent to 10 percent solids)
- Rinse water (from Empire Plating)

The ion exchange modules will be received from plating shops and segregated into chromium, cyanide-metals (e.g., cadmium) and other metals. The modules will be regenerated on a batch basis and all wastes will remain segregated. When chromium modules are regenerated, the resultant solution will be sent to a chromium recovery system (described in this section). The regeneration solutions from cyanide-metals and other metals will go directly to the "concentrated waste storage" as will wastes from the chromium recovery process. Spent process solutions from plating shops will be placed directly into the appropriate "concentrated waste storage" when they are received. Wastes in the storage area will be treated on a batch basis in the "preliminary batch treatment." Preliminary treatment includes chromium reduction, cyanide oxidation and neutralization. The pretreated wastes are then discharged to the precipitation process where they mix with rinse water from Empire.

The Empire wastes will be received at the facility as segregated waste streams (chromium, cyanide, other). The wastes will be fed to the continuous preliminary treatment processes (chromium reduction, cyanide oxidation and pH adjustment) and then to the precipitation process where they mix with the wastes from the batch treatment processes. After precipitation the treated water will be filtered in a sand filter to remove suspended solids. The solids from the precipitation process will be dewatered using a filter press.

Some Cleveland area shops may decide to install on-site treatment and send only their dilute sludge (underflow from clarifier) to the RRP treatment facility. These sludges will go directly to the dewatering process.

CHROMIUM RECOVERY

The previous Cleveland RRP project[2] investigated the economic and technical feasibility of metal recovery. The conclusion from this investigation was that chromium is a recoverable metal and that chromium recovery could be accomplished with a substantial return on investment. The other metal wastes generated by Cleveland platers (nickel, copper, zinc or cadmium) were not in sufficient volumes to justify recovery. Therefore only chromium recovery was included in the WECO RRP facility design.

CHROMATE RECOVERY SYSTEM

Chromic acid is widely used in the electroplating industry for chromium plating, metal stripping, and as an etchant for both metal and plastic parts prior to plating. In each case, the active constituent in the solution is the hexavalent chromium or chromate compound; trivalent chromium, which normally accumulates in these solutions, is considered a contaminant. Industrial wastes containing chromates fall into the following categories:

- Contaminated chromium plating baths - Concentrated chromic acid solutions contaminated with high levels of trivalent chromium and other metal cations (e.g., Fe, Cu, Ni).
- Spent chromate etchants - Moderate concentration chromate solutions contaminated primarily with trivalent chromium; if the etchant is for metal surface preparation, it will also contain metal cations.
- Spent copper stripping chromate solutions - Moderate concentration of chromates contaminated with trivalent chromium and copper cations.
- Rinses after chromium plating, etching or stripping processes - Dilute chromate solutions containing trivalent chromium and other metal cations, in addition to a background level of normal water contaminants (e.g., Na, Ca, CO_3, SO_4).

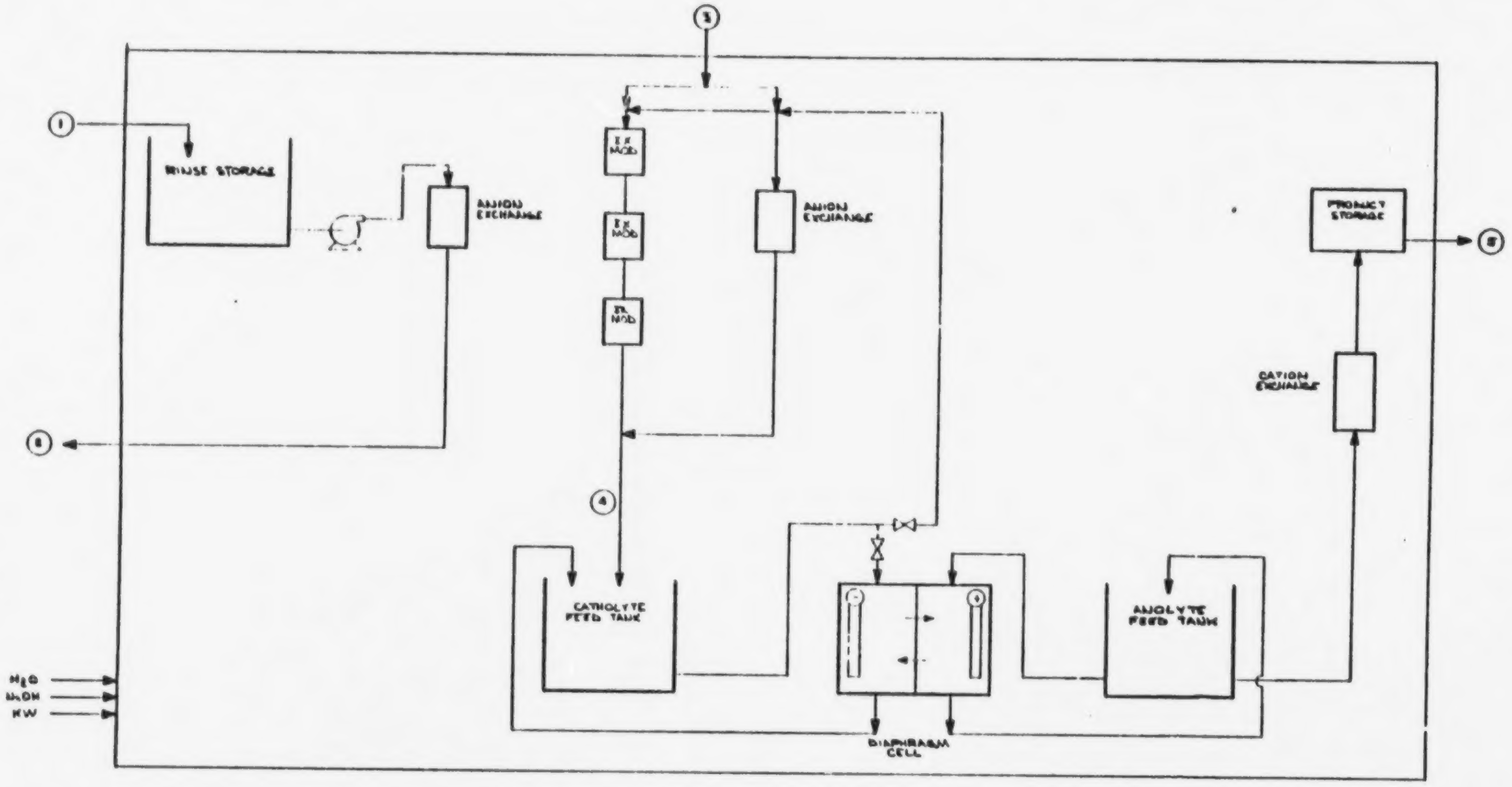
A recovery process that can both remove the cationic contaminants and concentrate the anionic chromate compounds would produce a product that could be utilized as either chromate etchant or strip solution. The product would not be suitable for use as a chromium plating solution because the purity requirements would necessitate further processing to also remove anionic contaminants. It is hoped, therefore, that concentrated chromic acid could be sold to local industry that utilize the treatment system.

If local industry is reluctant to purchase the chromate solution generated by the recovery process, it could be sold to one of the two firms engaged in chromium refining. Allied Chemical and Diamond Shamrock are the only firms producing chromate products from chromium ore. Both refineries are located on the east coast; Allied Chemical is in Baltimore, Maryland and Diamond Shamrock is in North Carolina. Allied Chemical indicated they would accept concentrated sodium chromate solutions if they were delivered to their Baltimore facility. No firm price was quoted, but it would be less than the current $.60 per pound market price of anhydrous sodium chromate. They indicated they would not accept chromic acid solutions.

The proposed recovery process is shown in Figure 6. It can accept both concentrated and dilute waste chromate solutions as well as extract and recover the chromate content on ion exchange modules. The process can generate either a concentrated chromic acid or sodium chromate solution.

The process employs two cycles of concentration; ion exchange either in the form of the fixed anion resin columns or the ion exchange modules, separates the chromates from cationic impurities and provides the feed for catholyte compartment of the diaphragm cell. In the diaphragm cell, the chromate concentration is increased in the anolyte up to the required level. The anolyte solution is then purged to the chromate storage tank; if a sodium chromate product is required, the chromic acid must be passed through a cation ion exchange column in the sodium form.

As shown in Figure 6, the fixed anion exchange columns and the ion exchange modules are partially regenerated with dilute chromic acid from the catholyte feed tank. This practice reduces regeneration chemical consumption. In this mode, the catholyte solution is gradually depleted of chromate ions in the diaphragm cell. The catholyte is then enriched by passage through the ion exchange bed and returned to the catholyte feed tank. The enriched solution is circulated through the diaphragm cell which extracts the chromate ions and concentrates them in the anolyte solution. In the diaphragm cell (Figure 7) the anolyte and catholyte are separated by a diaphragm that allows


1
RINSE STORAGE
ANION EXCHANGE
2
3
EX MOD
EX MOD
EX MOD
ANION EXCHANGE
4
CATHOLYTE FEED TANK
DIAPHRAGM CELL
ANOLYTE FEED TANK
CATION EXCHANGE
PRODUCT STORAGE
5
H2O
NaOH
KW

	① CONCENTRATED RINSES gpd	CONCENTRATE (mg Cr/l)	lb Cr/d	② WASTE WATER gpd	CONCENTRATE (mg Cr/l)	③ EX MODULES [illegible]	lb Cr/d	④ CATHOLYTE FEED CONCENTRATE (gm Cr/l)	⑤ PRODUCT ⚠ gpd	CONCENTRATION gm Na₂CrO₄/l	lb Na₂CrO₄/d	UTILITIES H₂O gpd	NaOH lb/d	ELECTRICITY Kw/d
CASE 1A	226	1175 TO 13545	2.0	4000	< 10	76.0	131.8	20.0	190	250	396	4000	550	
CASE 1B	0	N/A	N/A	4100	< 10	83.6	144.9	20.0	208	250	435	4100	610	
CASE 2A	4347	1175 TO 13545	53.6	13800	< 10	171.0	297.6	20.0	457	250	890	9100	1250	
CASE 2B	0	N/A	N/A	9700	< 10	195.9	318.1	20.0	451	250	941	9700	1320	

NOTES:

⚠ BASED ON 95% RECOVERY.

(To provide the reader with complete information, this reduced schematic drawing is included in the report. This is the best copy available; we regret that portions are undecipherable.)

Figure 6. Chromate Recovery System Mass Balance

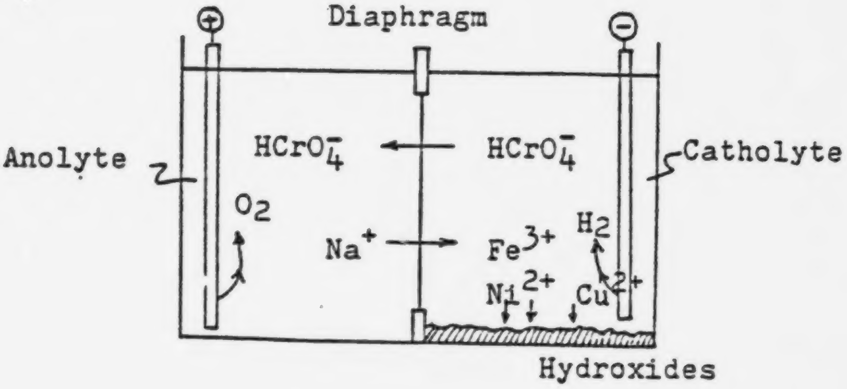

+
Diaphragm
−
Anolyte
$HCrO_4^-$
$HCrO_4^-$
Catholyte
O_2
Na^+
Fe^{3+}
H_2
Ni^{2+}
Cu^{2+}
Hydroxides

Figure 7. Diaphragm Cell for Chromic Acid Recovery

passage of ions by electromigration but prevents the solutions from mixing by diffusion. With the passage of electric current, chromate ions in the catholyte migrate through the diaphragm into the anolyte. The anolyte solution is circulated through the diaphragm cell until it reaches a concentration of 200 to 300 grams per liter of chromic acid.

During regeneration of the ion exchange beds, the beds are first regenerated with catholyte solution. After the catholyte solution removes the bulk of the chromate content from the resin beds, the resin is washed with NaOH and water to complete the regeneration. These regenerants are sent to the storage tank to ensure recovery of the chromate content. All other purge streams in the system are also sent to the storage tank. The combined rinses are then passed through the anion exchange to recover the chromate content before being sent to the waste treatment system.

CAPITAL COSTS

The capital investment required to construct the Resource Recovery Park at the WECO site is presented in Table 2. The total capital required is $3,343,200. As indicated in Table 2, the capital cost includes land and buildings, equipment, engineering, construction, startup and contingency costs. Detailed cost breakdowns of specific capital cost categories are presented in Tables 3 through 7.

OPERATING COSTS

The annual operating costs associated with the RRP are shown in Table 8. The major operating expenses are salaries and overhead ($140,620), treatment chemicals ($113,334) and sludge disposal ($71,125). Chemical costs were based on the chemical requirements to treat the waste of the 30-plant design plus the dilute rinse water from Empire Plating.

FEE STRUCTURE

Developing a fee structure for the RRP will be a difficult task since wastes will be received in various forms (i.e., ion exchange modules, concentrates, dilute rinse water, sludge). The previous RRP report[1] used hydraulic loading as a means of determining the price charged to each participant. The volume of waste from ion exchange was calculated as the amount of regenerant resulting from module regeneration (approximately 225 gal/module). Batch dump solutions were simply charged as per the volume received. Therefore, if a plant used 100 modules

TABLE 2. CLEVELAND RESOURCE RECOVERY PARK AT WECO PROJECT COSTS SUMMARY

Land and Buildings	$ 719,000	(See detail in Table 3)
Process Equipment	992,200	(See detail in Table 4)
Miscellaneous Items	112,300	(See detail in Table 6)
Project Engineering	200,000	
Project Construction	300,000	
Subtotal	2,323,500	
Contingency (10% of Total Construction Cost)	232,400	
Startup Costs	28,000	
Total RRP Cost	$2,583,900	
Investment in Ion Exchange Modules	759,300	(See detail in Table 7)
Total Capital Required	$3,343,200	

TABLE 3. LAND AND BUILDINGS (WECO) DETAILED COST BREAKDOWN

Land Acquisition 5 acres @ $35,000/acre	$175,000
Office Building 6,700 SF @ $20.00/SF	134,000
Industrial Building No. 1* 11,000 SF @ $12.00/SF	132,000
Industrial Building No. 2 5,000 SF @ $6.00/SF	30,000
Industrial Building No. 3 22,000 SF @ $9.00/SF	198,000
Building Renovation	50,000
Sub-total	$719,000

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*Includes T-16 (hydrated lime elevated storage tank with hopper)

TABLE 4. PROCESS EQUIPMENT DETAILED COST BREAKDOWN

Item	Unit Price*	Total Price
Chromic Acid Storage Tank Lined (18,000 gal)	$ 21,800	$ 21,800
Mixed Dump Stg Tank Tank Lined (75,000 gal)	27,600	55,200
Cyanide Stg Tank Mild Steel (2000 gal)	8,000	8,000
Waste Caustic Stg Mild Steel (2000 gal)	8,000	8,000
Dilute Sludge Stg (1000 gal)	5,000	5,000
Conc. Sludge Stg Bin	3,000	3,000
Batch Reaction Tanks FRP-3-4" (6'D X 4'H)	2,250	4,500
Batch Reaction Tanks FRP-3-4"	1,550,	3,100
Batch Reagent Tank	1,000	1,000
Batch Reagent Tank	1,000	1,000
Batch Surge Tank, Carbon St (5000 gal)	10,000	10,000
CN Batch Transf Pump	2,000	4,000
Batch Treat. Pumps	3,500	28,000
Batch Sludge Pump	1,500	3,000
Lamella Clarifier 140 GPM - 200 PPM Feed	69,000	69,000
DSF-38 Sand Filter	35,000	35,000
Agitators 3/4H	750	1,500
Agitators 2 MP	1,400	2,800
Mix Tanks (600 gal)	700	2,100
Continuous Reation Tank (5,000 gal)	3,500	3,500
Continuous Reaction Tank (6,000 gal) 10'D X 10'H w/Mix & Cover	4,500	9,000
Continuous Reacton Tank (2,000 gal) 6'D X 10'H W/Mix & Cover	2,500	2,500
Continuous Reaction Tank (5,000 gal) 10'D X 11'H w/Mix & Cover	3,000	3,000
Continuous Treat. Reagent Pumps Bleach Sul. Acid Bisulfate	700	4,200

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*Costs for equipment supplied by equipment vendors (1982).

(Continued)

TABLE 4 (continued).

Item	Unit Price	Total Price
Chlorinator	1,500	1,500
Sulfonator	1,500	1,500
Clarifier Eff pH Ind Only	1,500	1,500
Motor Control Centr	5,000	5,000
Press. Plate Filter	125,000	125,000
Cr Recovery System	291,000	291,000#
Control Panel	3,000	6,000
pH Loop Controls	5,000	5,000
DRP Loop Controls	5,000	5,000
pH Loop Control	5,000	5,000
Subtotal		$734,700
Contingency 10%		73,500
Piping		61,000
Installation		123,000
TOTAL		$992,200

#See additional detail on Table 5.

TABLE 5. CHROMATE RECOVERY SYSTEM COST

A. Chromic Acid Product	($)
1. Process Equipment (Installed Cost)	
a. 2 Bed Anion Exchanger @ 20 ft^3 with automated regeneration	$33,000
b. Tanks:	
Rinse Storage @ $10,000 gal	10,500
Catholyte Feed @ $5,000 gal	7,000
Anolyte Feed @ $2,000 gal	4,000
Product Storage @ $7,000 gal	8,500
c. Diaphragm Cell (estimate, no quotes obtained)	50,000
d. Pumps (4 required each with spare, low capacity)	12,000
e. Piping Instrumentation Reagent Supply (29 percent of process equipment)	25,000
f. Contingency (50 percent of process	63,000
g. Building Space	N.D.
Total Cost of Equipment	$213,000
Development and Design (20 percent of installed cost)	$ 43,000
Total Cost of Process Equipment	$256,000
B. Sodium Chromate Product	
H 1 Bed Cation Exchange Column @ 20 ft^3, manual regeneration	$ 12,000
G Added Contingency	23,000
Total Cost	$291,000

TABLE 6. MISCELLANEOUS ITEMS DETAILED COST BREAKDOWN

Item	Unit Price	Total Price
Spill Control	$15,000	$ 15,000
Paving/Parking (Sq ft) 2,000	15	30,000
Laboratory	29,000	29,000
Fork Lift LPG 5T Lift	32,000	32,000
Storage Barrel (209)	30	6,300
TOTAL		$ 112,300

TABLE 7. ION EXCHANGE MODULES DETAILED COST BREAKDOWN

Item	Unit Price*	Total Price
675 Anion Modules	$ 1,100	$ 742,500
28 Cation Modules	600	16,800
	TOTAL	$ 759,300

Note: Anion Exchange Modules consist of a 1.5'D x 5'H PVC vessel w/quick disconnect and 5 ft^3 anion resin.

Cation Exchange modules consist of a 1.5'D x 5'H PVC vessel w/quick disconnect and 5 ft^3 cation resin.

*Cost estimates for ion exchange modules were developed in Reference 2.

TABLE 8. OPERATING EXPENSES WECO RESOURCE RECOVERY PARK SITE

Cost Items	Quantity	Rate ($)/ Unit	Time (Days)	Item Cost ($)
Salaries and Wages:				
Plant Manager	1.00 Manyear	@ 32,000.00		32,000
Secretary	1.00 Manyear	@ 12,000.00		12,000
Operator	1.00 Manyear	@ 20,000.00		20,000
Chemist	1.00 Manyear	@ 25,000.00		25,000
Total Salaries and Wages				89,000
+ Associated Overhead		@ 58.00%		51,620
Total Salaries, Wages, and Overhead				140,620
Utilities:				
Electricity	119.40 kWh	0.07	250	2,090
Water	4,049.00 cu ft	0.01	250	14,880
Total Utilities Cost				16,970
Chemicals:				
Caustic	2,371.00 lb	0.14	250	82,985
SO_2	353.70 lb	0.11	250	9,727
H_2SO_4	336.60 lb	0.04	250	3,366
Poly-E	3.11 lb	2.50	250	1,944
Cl_2	875.00 lb	0,07	250	15,313
Total Chemical Cost				113,335
Percent of Capital Cost Items:				
Maintenance		6.00%		154,474
Insurance		2.00%		51,491
Total Maintenance and Insurance				205,965
Other Costs:				
Haul/Disposal	569.00 gal	0.50	250	71,125
Cr Recovery	102.50 gal	2.55	250	-65,344
Total Other Costs (Net)				5,781
Total Operating Expenses				482,671

per year and sent 6,000 gallons of batch dump solution to the RRP, they were charged for a loading of 28,500 gal (225 gal/mod x 100 mod + 6,000).

This approach to developing a fee structure is valid as long as each waste or regenerant has approximately the same pollutant concentration. However, if dilute rinse waters are pumped from nearby plating shops to the RRP, the hydraulic based fee structure must be adjusted. One approach to an alternate structure is to base the treatment price on the mass of pollutants received. This will more equitably account for treatment chemical requirements since chemical dosage is primarily based on pollutant mass.

Table 9 presents the results of this approach. In this example, the "Annual Production" is 226,050 treatment cost units. One treatment cost unit was defined as one pound of metal (either Cd, Zn, Cu or Fe). Since a pound of chromium or a pound of cyanide is more expensive to treat than, for instance, a pound of zinc, an adjustment was made for these pollutants. One pound of chromium was given a value of 1.1 treatment cost units and 1 pound of cyanide was given a value of 1.2 treatment cost units.

Using a manufacturing cost estimator program[2] the total unit cost of treatment was calculated to be $4.57. Therefore, if a plant shipped wastes to the RRP containing 100 lb of Zn, 25 lb of Cr and 10 lb of CN, the price charged for treatment would be $637.52 (100 lbs x 4.57 $/lb + 25 lb x 4.57 $/lb x 1.1 + 10 lb x 4.57 $/lb x 1.2).

TABLE 9. MANUFACTURING COST ESTIMATOR

29 April 1982
Ion Exchange 30 Plants + Empire

Facility Name	Cleveland Resource Recovery Park
Prepared For	Information
Prepared By	CENTEC
Annual Production	226,050
Units of Production	Treatment Cost Units
Capital Costs ($)	2,574,570

Cost Items	Quantity	Rate ($)	Time	Item Cost	Unit Cost
Salaries and Wages:					
Plant Manager	1.00 Manyear	@ 32,000.00		32,000	0.142
Secretary	1.00 Manyear	@ 12,000.00		12,000	0.053
Operator	1.00 Manyear	@ 20,000.00		20,000	0.088
Chemist	1.00 Manyear	@ 25,000.00		25,000	0.111
Total Salaries and Wages				89,000	0.394
Associated Overhead		@ 58.00%		51,620	0.228
Utilities:					
Electricity	119.40 kWh	@ 0.07	250 day	2,090	0.009
Water	4,049.00 cu ft	@ 0.01	250 day	14,880	0.066
Total Utilities				16,970	0.075
Chemicals:					
Caustic	2,371.00 lb	@ 0.14	250 day	82,985	0.367
SO_2	353.70 lb	@ 0.11	250 day	9,727	0.043
H_2SO_4	336.60 lb	@ 0.04	250 day	3,366	0.015
Poly-E	3.11 lb	@ 2.50	250 day	1,944	0.009
Cl_2	875.00 lb	@ 0.07	250 day	15,313	0.068
Total Chemicals				113,335	0.501
Percent of Capital Cost Items:					
Maintenance		@ 6.00%		154,474	0.683
Insurance		@ 2.00%		51,491	0.228
Capital Recovery		@ 17.70%		455,699	2.016
Total Percent of Capital Cost Items				661,664	2.927
Other Costs:					
Haul/Disposal	569.00 gal	@ 0.50	250 day	71,125	0.315
Cr Recovery	102.50 lbs	@ -2.55	250 day	-65,344	-0.289
Total Other Costs				5,781	0.026
Subtotal				938,370	4.151
Profit		@ 10.00%		93,837	0.415
Total Cost				1,032,207	4.566

SECTION 7

MARKETING STUDY

INTRODUCTION

The purpose of this section is to provide an estimate of the expected WECO RRP participation by Cleveland electroplating shops. To determine shops likely to use centralized treatment, the costs for on-site treatment (plater providing his own treatment) were estimated and then compared to the cost of using the RRP. The latter costs were estimated using the fee structure developed in Section 6. These fees are based on the 30-plant capacity design for WECO (capital cost = $3,343,200).

COSTS ASSOCIATED WITH NON-PARTICIPATION

While it has been noted that over 100 platers are in operation in the Cleveland area, the present marketing study has excluded those outside of city limits. Of the 76 platers remaining, 30 were visited and 5 of those were intensively studied during the previous RRP project.[1] Results of these investigations have been used to characterize the operations of all of the 76 plants considered.

Table 10 presents the annual costs for each plant should it decide to meet its pollution control requirements individually rather than through participation in the Resource Recovery Park. The annual costs for most plants are substantial. Moreover, considerable capital investment is required if the non-participation route is taken. The estimates of capital and operating costs for in-plant pretreatment are taken from Reference 2.

The first column of the table presents the plant identification number as coded in the CENTEC study. The next two columns present the investment costs and annual operating costs associated with required wastewater treatment equipment of the nature described in Reference 2. For most plants the cost associated with sludge handling and disposal has been calculated based on an assumed rate of $.50 per gallon. Those few plants in Cleveland found to generate over 150 gallons per day of sludge will find it economical to invest in sludge dewatering equip-

TABLE 10. COSTS OF ON-SITE TREATMENT

COSTS OF ON-SITE TREATMENT

PLANT ID #	WW TRTMT INVEST	WW OP COSTS	SLUDGE INVEST COST	SLUDGE OP COST	TOTAL ANNUAL COSTS FOR ONSITE TRMT
1	116000.00	13700.00	0.00	9000.00	50366
2	95000.00	15900.00	0.00	5300.00	43858
3	0.00	9300.00	0.00	2600.00	11900
4	75000.00	34700.00	0.00	12500.00	65088
5	60000.00	14000.00	0.00	1438.00	29748
6	167000.00	13400.00	0.00	2080.00	55310
7	118000.00	23700.00	0.00	7600.00	66598
8	53000.00	9300.00	30000.00	7700.00	36796
9	125000.00	15900.00	30000.00	8900.00	61768
10	12000.00	2200.00	30000.00	100.00	5162
12	35000.00	15000.00	0.00	2900.00	26248
13	12000.00	2200.00	0.00	4400.00	9462
14	143000.00	21000.00	0.00	10100.00	72361
15	60000.00	27700.00	30000.00	11232.00	53242
16	33000.00	9300.00	0.00	2600.00	19771
17	104000.00	20000.00	0.00	11300.00	56104
18	12000.00	2200.00	0.00	200.00	5262
19	12000.00	2200.00	0.00	6000.00	11062
20	53000.00	11200.00	0.00	2400.00	26241
21	12000.00	2200.00	0.00	0.00	5062
22	91000.00	12000.00	0.00	9100.00	42804
23	12000.00	2200.00	0.00	8500.00	13562
24	12000.00	2200.00	0.00	500.00	5562
25	57000.00	11600.00	0.00	2400.00	27595
26	70000.00	18300.00	0.00	13800.00	48795
27	95000.00	17200.00	0.00	7300.00	47158
28	50000.00	11600.00	0.00	2600.00	26125
30	12000.00	2200.00	0.00	300.00	5362
31	294000.00	98400.00	90000.00	31700.00	221684
32	56000.00	9500.00	0.00	8100.00	30956
33	118000.00	14200.00	0.00	12500.00	54843
34	92000.00	12000.00	0.00	8400.00	42342
36	12000.00	2200.00	0.00	4900.00	9962
37	101000.00	12900.00	0.00	11400.00	48389
38	26000.00	6000.00	0.00	1600.00	13801
39	33000.00	9300.00	0.00	2600.00	19771
40	36000.00	8000.00	0.00	5400.00	21986
42	95000.00	15500.00	0.00	3000.00	41158
43	0.00	9300.00	0.00	2600.00	11900
44	113000.00	12300.00	0.00	11300.00	50551
45	91000.00	15000.00	0.00	2100.00	38804
48	33000.00	9300.00	0.00	2600.00	19771
49	246000.00	76800.00	75000.00	26400.00	179759
50	101000.00	13200.00	30000.00	12500.00	56944
52	0.00	9300.00	0.00	2600.00	11900
53	0.00	9300.00	0.00	2600.00	11900
55	170000.00	21200.00	30000.00	8700.00	77600
58	33000.00	10200.00	0.00	800.00	18871
59	26000.00	6700.00	0.00	5400.00	18301
60	19000.00	5400.00	0.00	2600.00	12532
61	26000.00	6600.00	0.00	2100.00	14901
62	116000.00	13400.00	0.00	6600.00	47666
63	38000.00	9300.00	0.00	2600.00	20963
64	33000.00	9300.00	0.00	2600.00	19771
66	33000.00	9300.00	0.00	2600.00	19771
67	53000.00	9200.00	0.00	5600.00	27441
69	26000.00	6400.00	0.00	2400.00	15001
71	33000.00	9300.00	0.00	2600.00	19771
72	133000.00	17200.00	30000.00	7800.00	63876
73	476000.00	87000.00	90000.00	33400.00	255391
74	33000.00	9300.00	0.00	2600.00	19771
76	26000.00	6000.00	0.00	4100.00	16301
TOTAL	4417000.00	920700.00	465000.00	397650.00	2482707.00
MINIMUM	0	0.00	0.00	0.00	0.00
MAXIMUM	476000.00	98400.00	90000.00	33400.00	255391.00
AVERAGE	70111.11	14614.29	7380.95	6311.90	39408.05

ment. An investment cost for such equipment was assigned for those plants.

A capital recovery factor (CRF) was used to annualize the wastewater and sludge investment. A cost of funds of 12 percent and an equipment life of 10 years were used for this purpose. These annualized investment costs when added to the operating costs result in the total annual costs associated with wastewater treatment and sludge disposal, respectively. The last column of Table 10 presents the sum of the annual costs for wastewater treatment and for sludge disposal.

COSTS OF JOINING THE RESOURCE RECOVERY PARK

The Resource Recovery Park will provide ion exchange modules to all plants which have running rinses requiring treatment. The modules will be transported to the Resource Recovery Park when they require regeneration, and fresh modules will be left in their place. Batch dumps will be transported to the Resource Recovery Park for treatment in 55-gallon containers. Ion exchange modules will be leased to plants requiring them at a rate which allows the Resource Recovery Park to recover its investment over the expected useful life of the modules.

Table 9 presented the derivation of the RRP fee structure. The fees which are calculated for a 30-plant RRP capacity (76 plant and 30 plant) allow recovery of investment in 10 years with a 12 percent cost of funds. A profit of 10 percent of all costs is also included.

RRP MARKET ESTIMATE

Using the RRP fee calculation presented in Table 9, the cost of RRP participation for each shop was determined and compared to the cost for each shop to provide their own treatment. These results are presented in Table 11.

The first three columns of Table 11 show the plant ID, annual volume of ion exchange regenerant to be treated by the RRP, and annual volume of batch dumps to be treated. The next column shows for the shops that are expected to use the RRP, the total annual cost (including module rental, ion exchange installation, transportation and treatment). The difference between the annual cost of on-site treatment (Table 10) and the total costs of participation are given in the final column.

Batch dump volume, column 3, was obtained through plant survey for plants 1-30 as described in Reference 2. In order to estimate the volume of batch dumps at the remainder of the

(To provide the reader with complete information, this computer printout is included in the report. This is the best copy available; we regret that portions are undecipherable.)

TABLE 11. DETERMINATION OF PARTICIPANTS

Plant ID	Vol. of IX to be Treated	Volume of Dump to be Treated	Total Annual Costs of Partic.	On Site RRP Partic.
1	147825.00	6960.00	17470.90	32892.19
2	13275.00	3563.00	8403.15	35454.35
3	0.00	0.00	19687.75	0.00
4	0.00	0.00	209056.41	0.00
5	10700.00	3300.00	3080.18	24667.82
6	82800.00	9631.00	17958.21	37351.29
7	24300.00	2773.00	16398.42	30199.58
8	0.00	0.00	118422.24	0.00
9	178875.00	16640.00	39497.23	22270.27
10	0.00	320.00	165.20	4996.00
		[illegible]	[illegible]	[illegible]
12	0.00	867.00	199.27	24040.23
13	9900.00	13206.00	3808.43	5573.57
14	260550.00	30800.00	48755.94	23404.56
15	21150.00	1600.00	4192.78	49049.22
16	11250.00	5073.00	1646.40	10124.01
17	55125.00	845.00	13584.34	42519.64
18	0.00	347.00	140.22	5113.70
19	27675.00	9100.00	6493.64	4560.36
20	99450.00	10400.00	23256.21	2004.29
21	0.00	350.00	149.30	4912.70
22	180125.00	7150.00	9325.00	33477.70
23	0.00	2167.00	326.91	13235.09
24	0.00	650.00	177.97	5304.03
25	16650.00	750.00	5233.06	22361.44
26	39825.00	3840.00	7985.04	40009.96
27	112725.00	8840.00	28038.34	18319.16
28	22500.00	5200.00	3537.91	22507.09
30	0.00	3073.00	2324.40	3027.52
31	0.00	0.00	367433.30	0.00
32	31050.00	9917.00	9170.42	21785.50
33	25425.00	3092.00	7712.10	47120.02
34	10900.00	6738.00	4132.20	30219.72
36	1205.00	3037.00	5454.52	4207.40
37	7875.00	6014.00	3082.57	45305.93
38	6750.00	2110.00	2080.57	11720.43
39	10700.00	13060.00	5638.68	14141.02
40	20000.00	3032.00	7743.30	14242.62
41	6525.00	2551.00	4014.80	37142.70
43	0.00	17270.00	2301.29	9510.71
44	49725.00	2143.00	13141.50	37400.92
45	22500.00	2307.00	2866.71	36736.79
46	11250.00	1904.00	1221.17	10549.31
47	449125.00	40164.00	116823.87	62734.63
50	0.00	0.00	140803.13	0.00
52	0.00	14053.00	1950.50	9949.50
53	0.00	0.00	30179.06	0.00
55	262800.00	4393.00	63450.14	12141.86
58	33750.00	2026.00	3073.30	13797.12
59	30780.00	12707.00	11561.00	6740.00
60	22500.00	1954.00	4230.40	8293.10
61	7875.00	2105.00	2403.35	12497.65
62	6750.00	5630.00	2563.11	45102.09
63	11250.00	2312.00	1261.25	19701.75
64	11250.00	2509.00	1370.77	18391.73
66	11250.00	45902.00	7139.09	12631.41
67	7875.00	5118.00	2813.32	24627.10
69	0.00	0.00	10053.14	0.00
71	11250.00	4460.00	1506.29	10104.21
72	107100.00	16721.00	29299.63	34575.07
73	0.00	0.00	384130.32	0.00
74	11250.00	5663.00	1704.41	10066.09
76	28800.00	1933.00	7633.40	8665.52
--------	++++++++++	++++++++++	++++++++++	++++++++++
	2694330.00	391478.00	1861224.96	1214546.98

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Cleveland plants, a relation between total wastewater flow and batch dump volume was developed. A correlation coefficient of 0.815 between total flow and batch dump volume was found using data from 25 shops. Relations were obtained by linear regression.

Flow >10,000 gpd:

Dump vol (gpy) = 485 + 0.19 Flow (gpd)

Flow ≤10,000 gpd:

Dump vol (gpy) = 1,682 + .105 Flow (gpd)

Annual transportation costs for each plant were calculated based on the parameter values given below:

Cost of truck operation	$27/hour
Time required per pickup	4 hours
Modules per truckload	30
55-gallon drums per truckload	20

The rental costs for the modules have been calculated based on recovery of capital investment over the expected 10 year life at an assumed cost of funds of 20 percent (CRF = .2385). In addition, the expenses of maintenance and insurance (8 percent of the investment), and replacement of resin (one-tenth of the resin cost each year) are included in the rent. The annual rental fee is then $439 for an anion unit and $228 for a cation unit as shown in Reference 2.

All in-plant investment (both to install ion exchange if participating or to install treatment if not participating) has been annualized using the same 10 year life and 12 percent cost of funds for the purposes of Table 11.

The cost comparison indicates that 54 of the 76 Cleveland shops would use the RRP with the assumed fee structure. Additionally, Empire Plating has decided to use the RRP. The 54 shops would generate an ion exchange regenerant volume of approximately 2,694,330 gal/yr and send approximately 391,478 gal/yr of batch dumps to the RRP. The flow of dilute rinsewater pumped from Empire Plating would be 56.4×10^6 gal/yr.

Of the 54 shops that would be expected to use the RRP, 45 would send both ion exchange modules and batch dumps. The remaining 9 shops would send only batch dumps. The largest estimated waste flow from any one shop (excluding dilute rinses) was 649,125 gal/yr of ion exchange regenerant and 48,166 gal/yr of batch dumps (Plant 49). For that particular shop the cost of

RRP participation would be $116,023 per year which would provide a savings of $63,734 per year over on-site treatment.

This marketing analysis shows that a solid base of participation can be expected for the RRP. Most shops find incentives for participation sufficient.

ION EXCHANGE VS. CONCENTRATED SOLUTIONS

A possible alternative to the use and transport of ion exchange modules is the concentration of dragged-out pollutants in still rinse tanks with shipment of the resulting concentrated dragout solutions to the RRP. Figure 8 illustrates the process flows and the in-plant changes required of the plating shop.

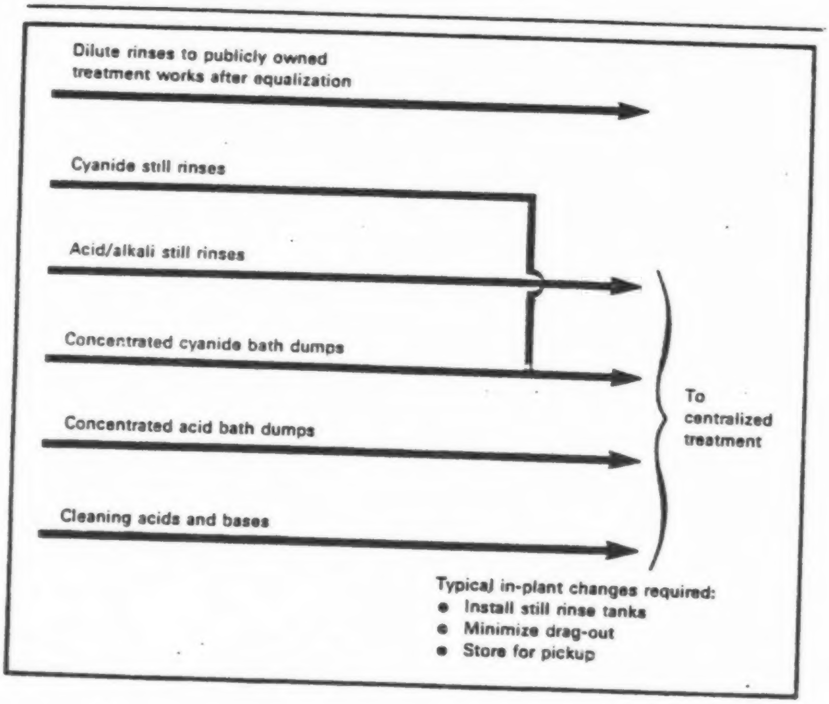

Dilute rinses to publicly owned treatment works after equalization
Cyanide still rinses
Acid/alkali still rinses
Concentrated cyanide bath dumps
Concentrated acid bath dumps
Cleaning acids and bases
To centralized treatment
Typical in-plant changes required:
• Install still rinse tanks
• Minimize drag-out
• Store for pickup

Figure 8. Concentrated Solution Shipment to the RRP

In order to estimate the impact of this alternative form of operation on the projected workings of the RRP, an approximate analysis was conducted utilizing data from the five shops that were surveyed in detail under the earlier CENTEC study.[2] Figure 9 shows schematically the assumptions and terms of the analysis.

The present arrangement, simplified, is shown in which the metal being plated exists at a concentration C_p in the process tank. The dragout, Q_d, results in a pollutant concentration C_e being carried to the sewer by the running rinse flow, Q. In general, C_e exceeds the allowable pollutant concentration C_s. The proposed arrangement involves the addition of a still rinse tank between the plating tank and the running rinse system. The running rinse flow rate, Q, is considered to be unchanged, as is the dragout rate, Q_d. Fresh water is added to the dragout tank at a rate Q_{RRP} equal to the rate at which concentrated dragout solution is withdrawn and stored for shipment to the RRP. The flow rate, Q_{RRP} is chosen to be such that the resulting pollutant concentration in the running rinse, C_s, meets effluent limitations thus allowing the rinse to be discharged to the sewer.

The sum of the pollutant mass shipped to the RRP and sent to the sewer in the proposed arrangement equals the mass being discharged presently:

$$QC_s + Q_{RRP}\,C_d = QC_e$$

and, in the proposed arrangement

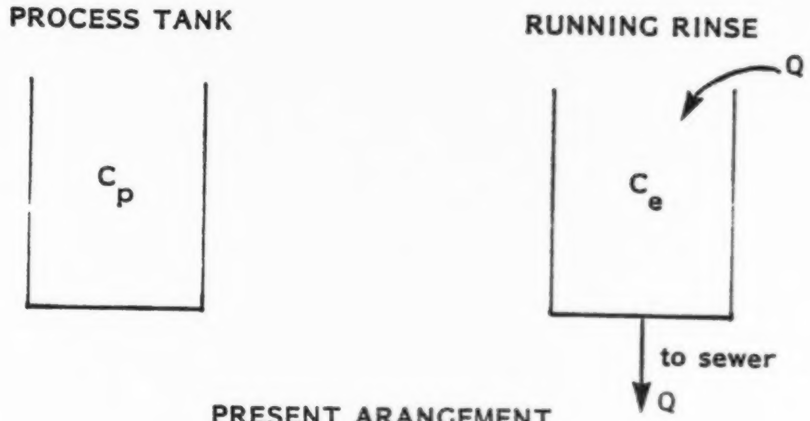
$$Q_dC_d = QC_s$$

Solving for Q_{RRP}:

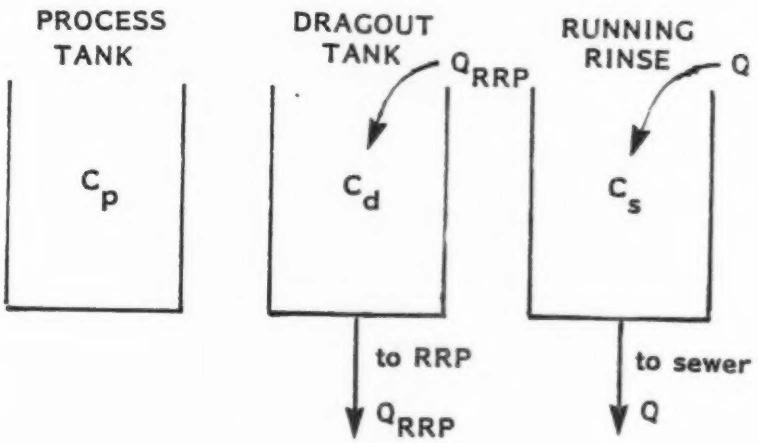
$$Q_{RRP} = Q_d\left(\frac{C_e}{C_s} - 1\right)$$

Since the dragout rate is assumed unchanged:

$$Q_d = Q\,\frac{C_e}{C_p}$$


PROCESS TANK
RUNNING RINSE
Q
C_p
C_e
to sewer
Q

PRESENT ARANGEMENT


PROCESS TANK
DRAGOUT TANK
Q_{RRP}
RUNNING RINSE
Q
C_p
C_d
C_s
to RRP
Q_{RRP}
to sewer
Q

PROPOSED ARRANGEMENT

Figure 9. Schematic for Concentrated Solution Analysis

Finally

$$Q_{RRP} = Q \frac{C_e}{C_p}\left(\frac{C_e}{C_s} - 1\right)$$

When each of several plating lines produces a pollutant at a concentration above the limitation, the total flow to the RRP is the sum of the individual flows calculated for each line.

Table 12 presents the calculations for the five Cleveland shops. Each of the shops except for Plant No. 5 requires the transport of a wastewater volume large enough to necessitate the provision of 5000 gallon storage tanks at the plant. Transport for those four shops is assumed to be by 5000 gallon tank truck at a rate of $40 per hour and a trip speed of 30 mph. Twenty minutes load and unload time is allowed. Plant No. 5 can ship its concentrated rinses in 55 gallon containers on the same basis as assumed for dumps elsewhere in this report.

Costs associated with the shipment of concentrated rinses to the RRP are presented in Table 13, as are the costs involved in the use and shipment of the ion exchange modules. (These latter costs are those already incorporated in Table 11.) It is assumed that fees for treatment based on pollutant content will be the same under either option. However, the larger flows requiring treatment at the RRP for the rinse concentrate option could require increased treatment system capital investment for that option and consequent higher fees. Transport and treatment of batch dumps are similarly assumed unchanged under either option.

Table 13 shows that the related costs for the two options favor the ion exchange approach when the number of modules being transported is fewer than about 8 each week. Figure 10 presents the same information and shows a crossover point at about 15 MGY (present plant total effluent).

The comparative analysis presented in this section has shown that the ion exchange method of operation is to be preferred for most plants in the WECO marketing area. Ion exchange has the added cost advantage of allowing shops to recycle rinse water, a cost advantage not included in this comparison. Nevertheless, the drag-out recovery method does hold advantages for large shops and should be a suggested option.

TABLE 12. CALCULATION OF RINSE CONCENTRATION FLOWS TO THE RRP

Plant #	Days/yr	Plating Line	C_p oz/gal	C_e mg/l	C_s mg/l	Q gal/day	Q_{RRP} gal/day	Q_{RRP} total gal/yr
4	250	Acid Zinc (Zn)	11	250	2.6	102,240	29,563	7,983,500
		CuCN (CN)	1	13.8	1.0		2,411	
5	250	CuCN (CN)	1	7.85	1.0	10,800	77.5	21,100
		Ni	10	12.5	2.6		6.9	
6	260	Zn	7.1	16.98	2.6	50,112	88.5	426,998
		Cd	10	4.43	.7		15.8	
		CuCN (CN)	1	15.67	1.0		1,538	
12	200	CuCN (Cu)	5	142	2.7	11,750	2,299	486,000
		Zn	2	22.2	2.6		131	
15	312	CuCN (CN)	1	17.3	1.0	27,984	1,054	330,720
		Zn	7.1	6.84	2.6		6	

TABLE 13. COMPARISON OF COSTS FOR RINSE CONCENTRATION AND ION EXCHANGE

Costs for Ion Exchange

Plant #	IX Modules per yr	In-Plant Costs (Annual)	Transport	Lease	Total for IX
4	10434	$763	$37,562	$185,020	$223,345
5	84	382	302	1,489	2,173
6	368	572	1,325	6,525	8,422
12*					
15	94	382	338	1,666	2,386

Costs for Rinse Concentration

Plant #	Conc. Rinse per yr, gal	Distance to WECO, miles	Storage Tanks	Dragout Tanks	In-Plant Costs (Annual)	Transport	Total For Rinse Conc.
4	7,983,500	8.8	6	8	$14,132	$79,835	$93,967
5	21,100	3.1	0	6	4,160	2,115	6,275
6	426,998	4.2	1	6	5,591	3,246	8,837
12	486,000	5.4	1	3	3,511	4,601	8,112
15	330,720	2.8	1	4	4,204	2,195	6,399

*Ion exchange was not included for this plant.

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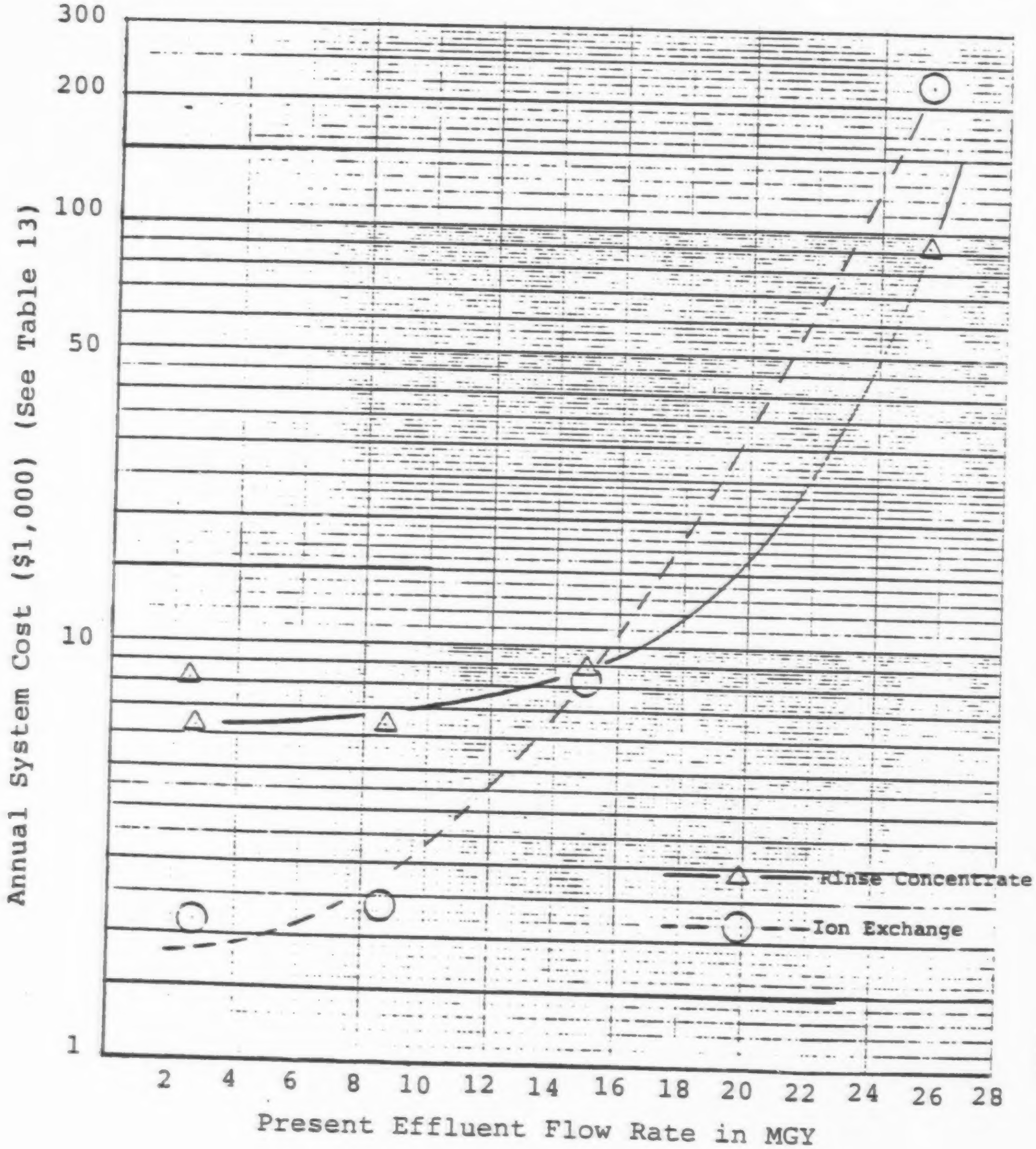

Figure 10. Annual Systems Cost vs. Flow Rate

SECTION 8

FINANCIAL STRUCTURE

REQUIRED INVESTMENT

The investment for construction and startup of the proposed facility will require a capital outlay of approximately $3.5 million. Working capital and chemical inventory costs totaling approximately $275,000 will be required in addition to the investment capital, but are treated separately and assumed to be financed by a revolving line of credit on a short-term basis. The investment capital, however, must consist of a combination of equity provided in some manner by the RRP owners and a debt portion to be financed through some type of long-term lending arrangement.

EQUITY TO DEBT RATIO

The amount of equity required by financial institutions to acquire financing for the project will generally range from 10 percent to 40 percent of the total project cost. The equity required will vary greatly depending on the method of financing sought, the credit of the party seeking financing, the estimated risk associated with the venture, and the amount of funds available through various loan programs including those guaranteed by various governmental bodies, including local, state and Federal agencies.

Obtaining a loan guarantee on the debt from one of these agencies is helpful in keeping the required percentage of equity as low as possible in light of other factors. A guarantee of 90 to 100 percent of the aggregate amount to be financed generally makes most institutions more willing to provide longer term, lower interest financing in larger amounts and with slightly less restrictions regarding the borrower's ability to operate its facility and secure required short-term credit. Similarly, a guarantee will increase the marketability and reduce the required interest rate for the issuance of bonds if this method of financing is sought. Guarantees are expensive, however. A 100 percent loan guarantee from the Small Business Administration (SBA) on a loan from another institution currently requires a commitment fee of 3-1/2 percent of the principal and interest.

EQUITY STRUCTURE

Under current economic conditions there are primarily three practical methods for raising the equity portion of the capital required by a private corporation to finance the project. The method preferred by the potential owners of the facility is to raise 25 to 40 percent of the project cost as equity through a limited partnership. The owners would be organized as a corporation and function as the general partner in the limited partnership. By offering a limited partnership, the corporate owners (general partner) would be raising equity in exchange for a share in future profits, depreciation, or tax deductions which would be distributed to the limited partners. In this particular case, a large part of the total project cost is devoted to the purchase of equipment indicating that the majority of tax deductions to the limited partners will be in the form of depreciation deductions and investment tax credits. Various other structures are possible to compensate the partners for their equity contribution, for example, royalty payments based on sales or some form of buyout arrangement with the limited partners. Typically, the limited partners will initially receive a large share of the depreciation benefits, profits, or other compensation, with their share declining over the life of the project.

In order to receive their share in benefits, the limited partners must also share in the liabilities of the project. Such liabilities must at least equal their proportionate share of benefits. The amount of equity contributed by a limited partner provides the maximum limit on the benefits or liabilities of that partner; hence the name "limited partner."

Two alternative methods of raising the required equity portion of the capital involve the issuance of stock in the corporation. One way stock may be issued is through a public offering. Such an offering requires SEC registration entailing approval procedures which may take as long as nine months. Although there are generally no restrictions regarding the number of investors or their qualifications, there are high costs for legal and underwriting fees associated with the aforementioned approval procedure. This cost, in conjunction with the approval period, makes the second method, a private placement of stock, more attractive.

When a private placement of stock is made, no Security Exchange Commission (SEC) registration is required, thus avoiding both the associated high legal and underwriting costs and long waiting period for approval. Participation is limited to 35 non-accredited investors.

However, a private placement may include an unlimited number of accredited investors. Rule 5.01 of Regulation D of the SEC's rules and regulations defines the term "accredited investor," and sets forth eight categories of accredited investors:

1. Institutional investors
2. Private business development companies
3. Tax exempt organizations
4. Directors, executive officers, and general partners
5. $150,000 purchases
6. Natural persons with a net worth of $1 million or more
7. Natural persons with an annual income of $200,000 or more
8. Entities made up of certain accredited investors

Although the limited number of investors may be stifling on larger projects, it should not be a significant problem with the cost of the proposed facility. If 25 percent equity is required, this translates to a minimum investment of approximately $28,600 for each of the 35 investors.

DEBT STRUCTURE

The general latitude in attractive debt financing alternatives has become rather limited due to changes in tax laws, fluctuating interest rates, and other economic factors. Two methods, however, appear to be attractive alternatives for financing the WECO treatment facility. The two methods involve either securing a loan from the state of Ohio's Department of Economic and Community Development under Ohio's Economic Development Financing Act--Senate Bill (S.B.) 313, or obtaining capital through the issuance of a Pollution Control Revenue Bond (PCRB) guaranteed by the Small Business Administration (SBA).

The acquisition of financing under SB 313 has been suggested by the Cleveland Area Growth Association to be the most viable debt financing structure for this particular project.

S.B. 313 was created to encourage development in various "Local Economic Needs Areas" of Ohio. In order for the site to qualify as such an area, the municipal corporation, township, or county seat in which it is contained must meet at least three of the following five criteria in comparison to statewide figures:

1. A higher average unemployment rate
2. A lower growth rate of unemployment
3. A lower growth rate of population
4. A lower absolute increase in per capita income
5. A lower growth rate in assessed valuation of real and personal property

In addition, the person, corporation, or partnership seeking assistance under S.B. 313 must have owned, rented, or leased, and operated property in Ohio for use in industry, commerce, distribution, research, or any combination thereof, prior to January 1, 1980.

Applicants meeting the aforementioned criteria are eligible for receiving Senate Bill 313 financing for up to 75 percent of the project costs at a rate 2 percentage points below the average rate of interest charged for all other direct loans during that year, and guaranteed for up to 90% of the allowable costs. Such allowable costs essentially include all costs except those for inventories, working capital, or refinancing of a project.

Although the qualified applicant is eligible for this financing, it does not guarantee his particular application will be granted. The Director of the Department of Economic and Community Development must review all applications from eligible parties considering all of the following criteria before giving the application his final approval:

1. The number of jobs to be created or preserved, directly or indirectly;
2. The payrolls and the taxes generated at both the state and local levels;
3. The size, nature and cost of the eligible project, including the prospect of the project for providing long-term jobs and enterprises consistent with the changing economics of the state;
4. The needs and degree of needs of the area; this, of course, will be reflected in the criteria set forth in determining a Local Economic Needs Area;

5. The needs of the private sector enterprise to be assisted;

6. The competitive effect of the assistance on other enterprises providing jobs for people of the state;

7. The amount and kind of assistance to be provided by other governmental agencies through tax exemption, tax abatement or other financial incentives;

8. The impact of the eligible project on local governmental services, including school services and on public facilities;

9. The effect of the assistance on the loss of or damage to or destruction of prime farm land;

10. Whether the project to be assisted will require increased automobile fuel consumption; and

11. Finally, consideration must be given to the size of the business to be helped. The General Assembly made special provisions for small business concerns in this act, specifying that at least 50 percent of the $500 million maximum assistance go to business concerns that have not more than 400 employees, not including the employment to be generated by the project.

Thus, in essence, applications receive final approval for assistance under S.B. 313 on the basis that the benefits to be derived by the state and Local Economic Needs Area from the establishment or development and operation of the eligible project will exceed the costs of providing such assistance.

If for some reason financing for the RRP cannot be arranged under S.B. 313, or in the event that either only a low percentage of the total capital is available through this mechanism, or limited partners are not available to raise the full amount of remaining equity, financing may be sought in the form of a Pollution Control Revenue Bond (PCRB) with a 100 percent SBA guarantee.

Unlike corporate financing, which is expensive in terms of interest and relies upon the corporate credit image of success, pollution control revenue bonds are issued by a public entity such as a municipality or a specially established state or local pollution control financing authority. The bonds are generally sold through the underwriter to the public. Monthly payments to cover the principal and interest charges are made by the project owner to a trustee, who uses the funds to pay the interest to the bond holders and redeem the bonds as they mature.

Because the interest earned on these bonds is exempt from federal income tax, investors are generally willing to purchase the bonds at a rate lower than that available for conventional financing.

A loan guarantee on such bonds, however, is essentially required to ensure their marketability and to keep the required interest rate as low as possible. Loan guarantees on PCRB's may be purchased from the SBA. For a fee of 3.5 percent of the principal plus the interest, the SBA pledges the full faith of the federal government in backing 100 percent of the loan.

To be eligible for the SBA PCRB guarantee program, the business must meet the following qualifications:

1. The business must have been in operation for at least five years,
2. The business must show that it has been profitable in at least three of the last five years,
3. There must be evidence of need for a pollution control facility,
4. The repayment term generally may not exceed 25 years, and
5. The aggregate amount to be financed generally may not exceed $5 million.

In addition, the applicant's general business trends must compare favorably with those of its industry, and the business must be able to generate cash flow sufficient to pay all debt service requirements on the proposed financing.

The business must also meet the SBA definition of a small business and other criteria which include the following considerations:

1. Quantitative:
    a. The number of employees of the firm and its affiliates must fall within the SBA guideline limits for the specific type of industry under consideration or
    b. Regardless of the number of employees, the business may be defined as a small business if the business, together with all its affiliates, has a net worth less than or equal to $6 million dollars and their average annual after-tax income is less than or equal to $2 million.

2. Qualitative:

   a. The small business must be at an operational or financial disadvantage as compared with similar business concerns with respect to the planning, design, or installation of pollution control facilities or the obtaining of financing for such facilities;

   b. The small business must have been in operation for a minimum of five years and profitable in at least three of the last five years; and

   c. The small business should have or be able to obtain certification from its state or local regulatory authority that its project, when completed, will reduce, abate, or control pollution.

Although the processing steps are laborious and time consuming for this type of financing, there are distinct advantages to this method. First, this type of financing has a lower interest rate than conventional loans. Secondly, the term of the loan is generally longer than that of a conventional loan. In addition, funds may often be raised in this manner by a business that would not qualify for a conventional loan.

There are, however, several disadvantages associated with an SBA guaranteed PCRB. One disadvantage is the front end cost. As previously stated, the SBA will charge a fee of 3.5 percent of the aggregate amount (principal and interest) financed for issuing its guarantee. In addition the SBA also charges a Processing and Administrative Fee which, for the amount of 75 percent of the total capital for this project, would amount to $2,675.00. Because the bonds are issued by a public entity, there may also be a small fee for their services. Fees, expenses, and other bond issuance expenses may, however, be paid from the bond proceeds. A method for reducing these costs may be to combine the financing requirements of several small companies into one bond offering.

Another problem associated with SBA guaranteed PCRB's is the extensive processing required for approval of the guarantee. There is very little flexibility in the structure and administration of the program.

In addition to the aforementioned problems, there is currently very limited funding available through the program. Although the program is still a viable source of funds, it should be recognized that the Fiscal 1981 budget was cut from $110 million to $100 million, and the Fiscal 1982 budget has been cut from $125 million to $95 million. Many applications have been submitted for processing and delays in review and approval of applications are common. As a result of these conditions, many underwriters are no longer actively marketing the bonds.

SELECTED STRUCTURE FOR FURTHER ANALYSIS

A discounted cash flow (DCF) analysis was performed for the financial structure favored at this time by potential investors. This structure involves obtaining 25 percent of the total capital through the establishment of a limited partnership and obtaining the remaining 75 percent of the total capital under Ohio's Economic Development Financing Act--S.B. 313.

The DCF analysis calculates the annual discount rate at which the net cash in-flows exactly balance the invested funds outflow over the life of the project. Table 14 presents the results of the DCF analysis indicating a DCF rate of return of 26.1 percent, an average percent return on investment of 13.3 percent, and a payback period on the total investment of 10.1 years.

Table 15 presents data used as input for the analysis. Table 16 presents the annual cash flow statement, and Table 17 shows calculations of selected quantities used as input data.

TABLE 14. RESULTS OF DCF ANALYSIS

DISCOUNTED CASH FLOW ANALYSIS
RESOURCE RECOVERY PARK: SITE SPECIFIC
18 MAY 1982

Project: Cleveland RRP:	30 Plants & Empire	
Total Capital & Startup Cost	$3,152,370	
Borrowed Capital at 9%	1,891,422	
DCF Rate of Return (%)		26.1
Ave. % Return on Investment		13.34
Payback Years for Total Investment		10.1

TABLE 15. DCF INPUT DATA SUMMARY SHEET

(Discounted Cash Flow)

```
*** 1 *** GENERAL DESCRIPTION
CASE DESCRIPTION
DEPRECIATION METHOD (SL/SD/DB/ND/AR/AS)    = CLEVELAND RRP: 30 PLANTS + EMPIRE
DATE                                       = AR
TAX CREDIT & LOSS CARRY FORWARD? (Y/N)     = 18 MAY 1982
COMPANY NAME                               = N
                                           = RESOURCE RECOVERY PARK: SITE SPECIFIC

*** 2 *** PROJECT COST & LIFE
BASE YEAR FOR CAPITAL OUTLAY
CAPITAL COST FOR REAL PROPERTY ($)         =       1981
CAPITAL COST FOR PERSONAL PROPERTY ($)     =    175.000
  YEARS    COST
   3      38.270
   5   2.020.100
  10     837.000
STARTUP COSTS ($)
LIFE OF PROJECT (YEARS)                    =     38.000
                                           =         15

*** 3 *** GROSS INCOME
GROSS INCOME FOR FIRST YEAR ($)            =    702.554
   YEARS   ESCALATION OF GROSS INCOME (%)
   2 - 15      15

*** 4 *** LABOR, MAINT., UTILITIES & MATERIALS
OPERATING LABOR ($)
LABOR OVERHEAD RATE (%)                    =     89,000
ESCALATION OF LABOR (%)                    =         53
MAINTENANCE (% OF CAPITAL COST)            =         10
ESCALATION OF MAINTENANCE (%)              =          6
UTILITIES AND MATERIALS COST ($)           =         10
   YEARS   ESCALATION OF UTILITIES & MATERIALS (%)  117,183
   1 - 15      10

*** 5 *** RESEARCH, SALES, AND G&A
RESEARCH EXPENSES ($)
ESCALATION OF RESEARCH EXPENSES (%)        =          0
SELLING EXPENSES ($)                       =          0
ESCALATION OF SELLING EXPENSES (%)         =          0
GENERAL & ADMINISTRATIVE EXPENSES ($)      =          0
ESCALATION OF G&A (%)                      =          0
                                           =          0

*** 6 *** TAXES AND INSURANCE
TAXES AND INSURANCE (% OF CAPITAL COST)    =          2
ESCALATION OF TAXES AND INSURANCE (%)      =         10
INVESTMENT TAX CREDIT RATE (%)             =         10
CAPITAL COST ELIGIBLE FOR TAX CREDIT (%)   =         94
CORPORATE TAX RATE (%)                     =         48

*** 7 *** FINANCING METHOD
LONG-TERM LOAN (% OF TOTAL INVESTMENT)     =         60
INTEREST ON LONG-TERM LOAN (%)             =          9
LOAN PAYBACK PERIOD (YEARS)                =         15
BALLOON PAYMENT (% OF LOAN)                =          0
CONSTRUCTION LOAN (% OF LOAN)              =          0
CONSTRUCTION LOAN INTEREST (%)             =          0
INTEREST PAID ON WORKING CAPITAL (%)       =         17
   YEARS   WORKING CAPITAL (DAYS OF SALES/YR)
   1 - 15      59.1
```

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TABLE 16. ANNUAL CASH FLOW STATEMENT

YEAR	0	1	2	3	4
GROSS INCOME	-1.260.948	[illegible]	[illegible]	929.814	1.268.951
OPERATING COST	0	597.753	558.326	614.381	675.619
LOAN PRINCIPAL	0	[illegible]	[illegible]	76.537	83.425
LOAN INTEREST	0	173.224	164.403	138.111	151.222
WORKG CAPTL INT	0	19.615	22.553	25.741	29.633
CASH FLOW (BT)	-1.260.948	-59.162	-7.451	54.555	128.654
STARTUP - DEPR	0	5.600	5.600	5.600	5.600
DEPRECIATION-AR	0	389.835	595.532	557.148	525.207
TAXABLE INCOME	0	-390.177	-538.366	-431.656	-318.727
INCOME TAX	0	-187.205	-258.615	-227.195	-152.989
TAX CREDIT	0	374.975	0	0	0
PROFIT (AT)	0	74.383	-279.950	-224.461	-165.738
CASH FLOW (AT)	-1.260.948	435.077	[illegible]	261.750	281.643
DCF	-1.260.948	321.255	157.850	130.543	111.392

YEAR	5	6	7	8	9
GROSS INCOME	1.229.276	1.413.692	1.625.744	1.869.404	2.153.046
OPERATING COST	743.401	817.741	879.515	787.466	1.033.413
LOAN PRINCIPAL	70.934	79.118	108.338	117.762	128.260
LOAN INTEREST	187.714	177.330	126.529	116.686	105.287
WORKG CAPTL INT	14.308	37.453	45.172	52.172	53.334
CASH FLOW (BT)	213.940	321.348	446.210	593.314	766.981
STARTUP - DEPR	5.600	0	0	0	0
DEPRECIATION-AR	525.208	130.567	91.676	91.677	91.677
TAXABLE INCOME	-232.934	320.399	462.573	619.399	803.665
INCOME TAX	-117.009	153.791	222.035	297.311	385.759
TAX CREDIT	0	0	0	0	0
PROFIT (AT)	-115.926	166.607	240.538	322.087	417.906
CASH FLOW (AT)	323.949	168.257	224.175	256.003	381.223
DCF	131.607	41.101	44.219	46.302	47.291

YEAR	10	11	12	13	14
GROSS INCOME	2.472.553	2.843.436	3.267.752	3.760.385	4.324.811
OPERATING COST	1.197.254	1.216.379	1.492.477	1.593.545	1.752.900
LOAN PRINCIPAL	139.911	152.528	[illegible]	131.191	197.478
LOAN INTEREST	74.735	52.143	68.417	53.457	37.149
WORKG CAPTL INT	69.005	79.356	91.259	104.948	120.490
CASH FLOW (BT)	971.647	1.212.454	1.495.568	1.827.304	2.216.274
STARTUP - DEPR	0	0	0	0	0
DEPRECIATION-AR	91.676	11.667	11.667	11.665	11.667
TAXABLE INCOME	1.019.884	1.353.271	1.649.731	1.796.833	2.402.135
INCOME TAX	489.544	649.560	791.967	958.478	1.153.010
TAX CREDIT	0	0	0	0	0
PROFIT (AT)	530.340	703.711	857.964	1.038.351	1.249.095
CASH FLOW (AT)	482.102	562.879	703.401	868.826	1.063.244
DCF	47.428	43.913	43.518	42.628	41.370

YEAR	15	TOTALS
GROSS INCOME	4.972.188	32.181.134
OPERATING COST	1.908.190	16.132.563
LOAN PRINCIPAL	115.273	[illegible]
LOAN INTEREST	[illegible]	[illegible]
WORKG CAPTL INT	138.793	[illegible]
CASH FLOW (BT)	[illegible]	[illegible]
STARTUP - DEPR	0	28.000
DEPRECIATION-AR	11.667	[illegible]
TAXABLE INCOME	2.875.153	[illegible]
INCOME TAX	1.380.078	[illegible]
TAX CREDIT	0	[illegible]
PROFIT (AT)	1.495.085	[illegible]
CASH FLOW (AT)	1.291.479	[illegible]
DCF	39.350	[illegible]

(To provide the reader with complete information, this computer printout is included in the report. This is the best copy available; we regret that portions are undecipherable.)

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TABLE 17. CALCULATION OF TERMS MARKED 1-6 ON INPUT

			$
1.	Capital Cost for Real Property:	Land	175,000
2.	Personal Property:		
	3 yrs depreciation:	Forklift and barrels	38,270
	5 yr depreciation:		
	Treatment equipment (installed plus startup)		1,033,800
	Ion exchange modules		759,300
	Engineering		200,000
	Laboratory equipment		29,000
			2,022,100
	10 yr ACRS depreciation:		
	Building and structure		589,000
	Project construction		300,000
			889,000
	5 yr straight line amortization		
	Organization cost		28,000
3.	Gross Operating Income		
	Treatment (54 plants + Empire plant)		559,185
	Rental (see following page)		303,069
			862,254
4.	Utilities & Materials:	Utilities	11,539
		Chemicals	77,067
		Other costs	3,931
		Resin	24,646
			117,183
5.	Capital Cost Eligible for Tax Credit:		
	3 yr depreciation property		38,270
	5 yr depreciation property		2,022,100
	10 yr depreciation property		889,000
	$\frac{2,949,370}{3,124,370}$ (100) = 94.4%		2,949,370

(Continued)

TABLE 17. (Continued)

6. Working Capital (WC):

$$(153{,}795 \text{ Units/yr}) \; \frac{1 \text{ Yr}}{250 \text{ days}} \; \frac{\$4.57}{\text{unit}} = \$2{,}811/\text{day "sales"}$$

$$\text{WC Estimate } \frac{\$166{,}010}{\$2{,}811/\text{day "sales"}} = \underline{59.1 \text{ Days Sales}}$$

NOTE: Working capital (WC) included no provision for ion exchange resin gradual replacement so WC term "Days Sales" was based only on revenue from treatment.

Breakdown of costs and income for rental of ion exchange modules:

30 Plant Case

Ion Exchange Module Capital Cost		$ 762,815
	Cost of Resin	601,125
	Life of Resin	10 Yr
	Capital Rec. Factor	.2385 of Total Capital
	Resin Replac. Factor	.1 of Resin Cost

Rental Fee = $303,069/yr as calculated below:

(capital recovery) + (tax, insur. & maint.) + (resin replacement)

(.2385/yr)($762,815) + (0.08/yr)($762,815) + (0.1/yr)($601,125) = $303,069/yr.

181,931 + 61,025 + 60,113 = 303,069

This will be added to the revenues in the DCF analysis.

Material Cost of Resin

(0.1/yr)($601,125) = $60,113/yr.

SECTION 9

SAVINGS AT THE WECO SITE THROUGH THE USE OF CENTRALIZED ENERGY COGENERATION

Benefits are available to plants at the WECO site through the use of centralized cogeneration, in which process steam and electricity are produced at one central facility for use by the WECO plants. Cogeneration is not essential to the success of the WECO RRP, but would provide WECO plants with an inexpensive source of thermal and electrical energy, cutting operating costs significantly in view of escalating energy costs.

THE CONCEPT OF CENTRALIZED ENERGY COGENERATION

Most industrial plants consume both electrical energy, generally purchased from a public utility, and thermal energy, in the form of process steam, usually generated at the plant site using gas or residual-oil-fired boilers. Each of the processes for generating a usable form of electrical or thermal energy has certain inefficiencies associated with it. The goal of centralized cogeneration is to combine steam and electrical generation capabilities into one facility to boost the efficiency of converting the fuel energy to a usable form, and thus save money by reducing the total fuel consumption for a given output. The savings result not only from eliminating the inefficiency of producing steam and electricity in separate facilities but also from eliminating the energy lost due to the inefficiencies associated with operating numerous smaller boilers.

Cogeneration facilities are generally of two types: either steam turbine/generator, or gas turbine/generator waste heat boiler. Both types require a larger capital investment than conventional boilers that produce only steam; however, the cogeneration capability to conserve fuel often offsets this additional cost. In general, the gas turbine/generator waste heat boiler is from two to four times as capital intensive as the steam turbine generator system. For this reason, the gas turbine/generator waste heat boiler system will not be considered for the WECO site.

ECONOMICS OF CENTRALIZED ENERGY COGENERATION FOR THE WECO RESOURCE RECOVERY PARK

The location of several industries in close proximity in the WECO area makes the use of a centralized cogeneration facility an attractive method of supplying both the electrical and thermal energy requirements of the plants. The economics of the cogeneration facility vary with size and become increasingly attractive as the size increases. The economics are also a function of the fuel used to fire the boiler. Coal is the least expensive fuel and natural gas is the next best alternative. Both cases are presented in this report.

As illustrated in Figure 11, the cost of coal per million Btu remains significantly below the cost of other energy sources. Natural gas, although less expensive than oil or electricity, is legislated for price deregulation in 1985, at which time prices are expected to increase significantly.

In the economic study, estimating the savings available to WECO industries, the centralized cogeneration facility was sized for use by the six existing plants in WECO plus two hypothetical electroplating plants (each equal in size to the existing plating shop) that may possibly relocate to the area.

CONCLUSIONS

The analysis of cogeneration has shown that, in both cases investigated, cogeneration using a steam turbine/generator will result in savings when the cogeneration facility is sized for utilization of 100 percent of the thermal energy produced. The use of a coal-fired boiler system would be approximately 2.6 times as profitable as a natural gas-fired system.

The gross annual savings after depreciation for the base year of 1985 are $1,166,000 for the coal-fired cogeneration system and $445,000 for the natural gas-fired system. The costs and savings associated with each cogeneration system and for the case of separate facilities are detailed in Table 18. The annual savings are expected to escalate with time as a function of rising energy costs. Based on historical data, the rate of escalation is expected to exceed the rate of cost escalation for other goods and services. The analyses were based on 1985 costs which are estimated for the energy sources in Table 19.

DISCUSSION

In sizing the cogeneration facility, data from six existing WECO plants were used. This data is presented in Table 20. In

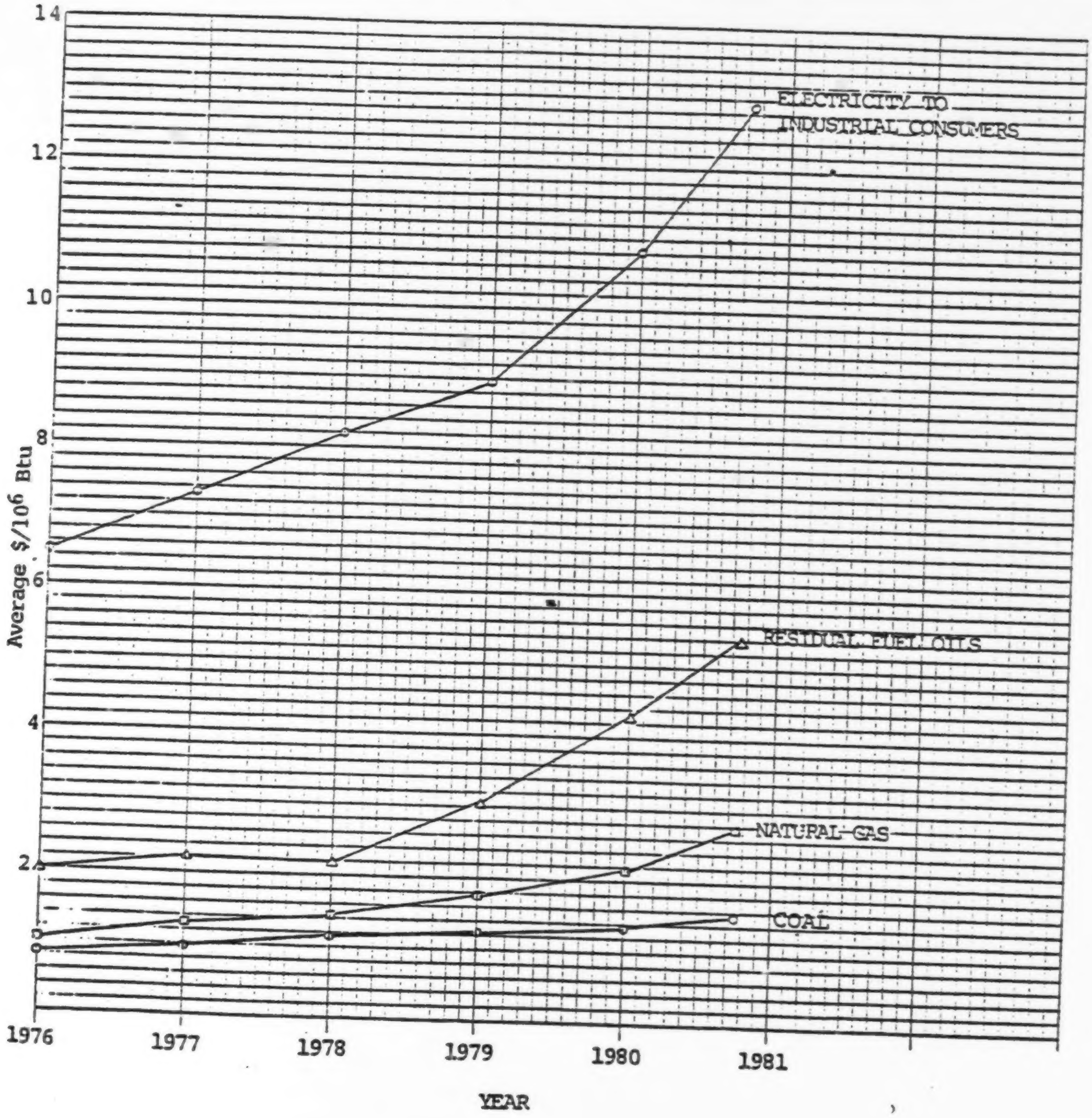

Figure 11. Escalation of Average Energy Costs from 1976 to 1981*

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*U.S. Department of Energy, Monthly Energy Review, January 1982, DOE/EIA-0035 (82/01) Energy Information Administration, p. 86.

TABLE 18. SUMMARY OF COGENERATION COSTS AND SAVINGS FOR WECO

1985 Dollars

	Separate Facilities	Gas-Fired Cogeneration	Coal-Fired Cogeneration
Installed Capital Cost, $/yr	$ 0	$1,028,000	$1,175,000
Fuel Cost, $/yr	1,743,000	1,896,000	1,160,000
Electrical Cost, $/yr	2,903,000	2,202,000	2,202,000
Amortization (10 yr. st. line), $/yr	0	102,000	117,500
Fuel Savings <Cost>, $/yr	—	<153,000>	583,000
Elec. Savings <Cost>, $/yr	—	701,000	701,000
Total Gross Saving <Cost>, $/yr 80,009	—	548,000	1,284,000
Gross Savings <Cost> after Dep, $/yr	—	445,000	1,166,000

TABLE 19. VALUES USED IN COGENERATION COMPUTATIONS

Estimated 1985 Costs

Item	Units	Year 1985 Base Cost
Gas	\$/MM Btu	5.00
Electrical	\$/MM Btu	24.03
Coal	\$/MM Btu	3.06

Note: Based on historical data from U.S. Department of Energy, Monthly Energy Review, March 1983, DOE/EIA - 0035 (82103)) Energy Information Administration, p. 86.

TABLE 20. ENERGY UTILIZATION DATA FROM EXISTING WECO PLANTS

Plant	A	B	C	D	E	F
Hours/Day Operation	24	8	24	16	16	20
% of Total Daily Energy Consumption per Shift	33/33/33	100/0/0	33/33/33	50/50/0	89/11/10	40/40/20
Days/Yr Operation	275	250	250	260	300	208*
Thermal Peak Load MMBtu/h	7.04	1.78*	0.714*	4.33	0	21.0*
Electrical Peak Load MMBtu/h	3.69	0.32	0.41	0.98	8.42	5.48*
Thermal/Electric Ratio	1.908	5.55	1.74	4.42	0	3.84*
Total Peak Load MMBtu/h	10.73	2.1	1.124	5.31	8.42	26.5

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*Estimated due to incomplete data.

addition to the data, numerous definitions and assumptions were required, dealing primarily with operating parameters of the proposed cogeneration facility and with selecting the load for which to size the facility. These definitions and assumptions are listed in Table 21.

The savings to the individual plants using the cogeneration facility would result from their decrease in energy costs and would therefore be directly proportional to the quantity of energy used at the individual plants.

Although the cogeneration facility was sized for the load during the peak shift, additional savings resulting from operation on other shifts are included in the analyses. These additional savings result from a direct savings in fuel cost and from an increased efficiency over separate thermal and electrical energy production rather than resulting from any increase in economy of scale. The amount of savings may not be directly proportional to the amount of output used, however, since the cogeneration plant efficiency may be somewhat lower operating at a decreased capacity than at its design capacity.

TABLE 21. ASSUMPTIONS INCORPORATED IN COGENERATION ANALYSIS

- Cogeneration plant was sized to supply 100% of the thermal load during the peak shift.
- Economics were based on 250 days/yr operation.
- Coal Fired Boiler Steam Turbine Generator
  - 600 psig/750°F Boiler Steam (262°F Superheat)
  - Initial Enthalpy @ Turbine Throttle = 1,379 Btu/lb
  - Turbine Efficiency = 70%
  - Generator Efficiency = 95%
  - Feedwater Temp. = 50°F
  - Boiler Efficiency = 80%
  - Steam Turbine Exhaust Steam Enthalpy = 1,181 Btu/lb
  - Steam Required/kW of Generator Output = 25.9 lb/kW @ 70% turbine efficiency and 95% generator efficiency.
- Thermal and/or electrical usage was estimated for some users
- For separate facility analysis, facilities were assumed to use gas-fired boilers operating at 75% efficiency.

REFERENCES

1. "Environmental Pollution Control Alternatives: Centralized Waste Treatment Alternatives for the Electroplating Industry," EPA 625/5-81-017, June 1981.

2. Cushnie, G. C., Harrison, D., et al, "Cleveland Resource Recovery Park--Preliminary Engineering Design," Final Report on Work Effort 12, Contract 68-03-2907, January 1982.

3. Comfort, E. H., Roberts, C. G., Cushnie, G. C., "Financing--Cleveland Resource Recovery Park," Final Report on Work Effort 14, Contract 68-03-2907, March 1982.

4. SBA Rules and Regulations, Part 121, "Small Business Size Standards," October 5, 1978.